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APPARATUS AND ACCOMPANYING METHODS FOR PROVIDING,  
THROUGH A CENTRALIZED SERVER SITE, AN INTEGRATED  
VIRTUAL OFFICE ENVIRONMENT, REMOTELY ACCESSIBLE VIA A  
NETWORK-CONNECTED WEB BROWSER, WITH REMOTE NETWORK  
MONITORING AND MANAGEMENT CAPABILITIES

CLAIM TO PRIORITY

5 This application claims the benefit of our  
co-pending United States provisional patent application  
titled "REMOTE NETWORK MONITORING AND MANAGEMENT" filed  
on April 13, 2000 and assigned serial number 60/197,404,  
which is incorporated by reference herein.

BACKGROUND OF THE DISCLOSURE

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1. Field of the Invention

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The invention relates to apparatus and  
accompanying methods for use therein for implementing a  
secure, cost-effective, web-enabled, integrated, virtual  
office user environment, through a centralized server(s),  
through which a remotely stationed user can access  
typical office network-based applications, including,  
e.g., e-mail, file sharing and hosted thin-client  
application programs, through a remotely located network,  
e.g., WAN, connected web browser, as well as for remotely  
providing network monitoring and management capabilities  
through a centralized administrative web site. The  
present invention is particularly, though not

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exclusively, suited for use in small to medium size organizations which, for economic reasons, do not have adequate in-house computer support (technical and administrative) capabilities.

5

## 2. Description of the Prior Art

With laptop personal computers (PCs) having become rather ubiquitous over the last several years, individuals who are away from their office, typically desktop, PCs and hence not in communication with their office networks, because they are either traveling or are at home, often have a continuing need to gain access to those networks. Such access is required if, for no other reasons, than only for those users to transfer files between their laptop PCs and servers on these networks and/or access their network-based e-mail servers (both for receiving incoming and transmitting outgoing messages).

20

This need is not only shared by many individuals but also by organizations of widely varying size, from large organizations to very small businesses and other groups.

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The art teaches various approaches to meet this need. However, they are all deficient in one respect or another. In that regard, none of these approaches offers

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an effective, integrated solution that readily provides all the functionality obtainable using an office network through one simple remote user interface, such as a web browser.

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Specifically, one approach is to simply install appropriate conventional communications software in each client laptop PC and permit its user to access, through a dial-up telephone line, his(her) office network to gain  
10 access to the network server for file transfer and e-mail functionality. All application programs would reside on and locally execute on the client laptop PC. While this approach is quite simple, nevertheless it necessitates that each and every such application program be  
15 installed, configured and then maintained on that PC. Consequently, over time, this approach, particularly in view of the on-going support costs of the installed application programs, can become quite expensive.

20

Another approach involves using a traditional virtual private network (VPN) to provide wide area network (WAN) connectivity from a user's remote or home location to an office local area network (LAN). A VPN WAN connection implements a so-called OSI layer 2  
25 extension or "conduit" of the office network itself between the LAN and the user's remote/home location. A remote client PC, connected through a VPN to an office LAN, locally appears on the LAN, as far as that user is

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concerned, as if that client PC were directly connected to it. In essence, for packets destined from the client PC to the LAN, a VPN connection therebetween involves, at a near end of the VPN connection, encapsulating outgoing  
5 OSI layer 3 packets at the client PC into layer 2 IP (Internet protocol) packets and transmitting those layer 2 packets over the VPN connection (in effect tunneling those layer 3 packets through the VPN connection), and subsequently, at a remote (LAN) end of  
10 the VPN connection, disassembling the layer 2 packets to yield the layer 3 packets and applying the resulting layer 3 packets onto the LAN for carriage to their ultimate destination, such as a network server. The opposite operation occurs in reverse for packets  
15 emanating from LAN, e.g., the server, and destined, over the VPN connection, to the remote client PC. Since the layer 2 packet tunneling is totally transparent to both the LAN and the client PC, advantageously the client PC can provide the same level of functionality to its user  
20 as if that PC were directly connected to the LAN.

Historically, a VPN connection required special, expensive VPN termination equipment located at each end of the connection, or required special client  
25 software to be installed and configured at the client machine. This equipment was rather expensive to acquire, and proved to be rather tedious to properly configure and hence costly to administer and maintain, particularly for



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those small to medium sized organizations that lacked adequate in-house technical support personnel.

5 In particular, at the remote client site, a so-called VPN terminator (also referred to as a "client-site VPN router") was connected to a client PC to bi-directionally interface that PC to the VPN connection. This terminator provided layer 2 packet processing as well as appropriate packet encryption/decryption  
10 functionality. However, such a terminator, which included special-purpose software, was generally quite expensive to procure and needed to be installed and properly configured for its particular client PC -- the latter entailing significant costs in both time and  
15 money. To mitigate the cost somewhat, various currently available PC operating systems (O/S's) now provide VPN support features, and, as an alternative, VPN vendors have built client VPN software that runs on the client machine and interacts with that vendors' own VPN server  
20 or with VPN servers from other vendors. Such client VPN software has been built to work with conventional PC O/S's such as Windows 98, Windows NT, Windows 2000, etc. However, PC O/S-based or client software based VPN support requires considerable packet processing (e.g.,  
25 for packet encapsulation and disassembly, and cryptographic processing), which disadvantageously imposes a significant processing burden on the PC -- though this burden may be acceptable for a home PC with a

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relatively light processing load, rather than a remote PC connected to an office network.

Furthermore, VPN services must be very secure.

5 Unfortunately, until rather recently such PC O/S-based  
VPN support used a rather small key size, such as  
40-bits, which generally does not provide sufficient  
security against third-party intrusion. While relatively  
new PC-based operating systems have become available that  
10 exhibit significantly increased VPN security, through use  
of triple DES and IPsec features -- such as Microsoft  
Windows 2000 O/S ("Windows 2000" is a trademark of the  
Microsoft Corporation of Redmond, Washington), this  
support still presents a considerable processing load to  
15 the PC; hence, denigrating PC performance, specifically  
processing throughput.

Moreover, such PC operating systems, whether  
those exhibiting increased VPN security or not, still do  
20 not provide requisite reliability.

As such, to provide VPN connectivity with  
required levels of security and reliability without  
imposing an undue processing load on the client PC, use  
25 of a separate dedicated client-site VPN terminator --  
even in view of its expense -- is still strongly favored  
in practice.

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Not only is expensive, specialized VPN equipment required at the client site (or alternatives such as OS-based VPN support or client software packages, both with their accompanying problems, need to be used),  
5 but it is also necessary, to an even greater extent, at the LAN (central) site. At the LAN site, VPN support requires installation and configuration of an office-site VPN router. Office-site routers are considerably more expensive than client-site VPN routers for the simple  
10 reason that the processing circuitry in the former, which implements the necessary cryptographic and packet processing operations, is sized based on a number of users that need to be simultaneously supported. Each user is allocated a certain slice of the available  
15 processing capacity. Even if such a router is sized to support just a few simultaneous remote users on the LAN, its cost can easily amount to several thousands of dollars, with the cost rapidly escalating as user load and hence necessary processing capacity of the VPN router  
20 increased. Recently, server operating systems, such as the Microsoft Windows 2000 server O/S, have become available that incorporate multi-user VPN support with sufficient security features; however, such support drains considerable processing resources from the server  
25 and still is insufficiently reliable. Moreover, if such a server O/S-based approach is used, counterpart client-site software, such as the Windows 2000 O/S, must be installed and properly configured on each client PC,

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which, if a large number of remote users exists, can be rather expensive and time consuming.

Therefore, in view of the relatively high cost  
5 involved, most small to medium sized organizations were  
and continue to be unable to afford the use of VPN  
connectivity, thus precluding themselves from providing  
secure remote office access to their internal networks  
and various business efficiencies and productivity  
10 increases that could have gained thereby.

A further, though totally different approach,  
evolved in the art for providing remote connectivity to  
an office LAN. This approach, predicated on an  
15 "application service provider" (ASP) model, involves  
installing specialized server software, such as  
"Metaframe" software available from Citrix Corporation,  
in the network server and an "ICA" client program in each  
client PC. Through the Metaframe program, the network  
20 server situated on the LAN would function as an ASP by  
hosting multiple virtual sessions of a given application  
program executing on the server, in effect implementing  
multiple virtual machines, to various different remotely  
located client PCs. Each remote client, running the ICA  
25 client program, would access, over, e.g., a WAN  
connection, a desired thin-client application hosted at  
the LAN-based server and establish a separate application  
session. The ICA client would communicate mouse clicks

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and keystrokes entered by a user stationed at the client PC, over the WAN connection, to the Metaframe program executing in the server which, in turn, would provide screen shots back to the client PC for local display to a user stationed thereat. This information would be carried between the client and server using an "ICA" protocol.

As PC manufacturers began equipping their PCs with client web browsers as standard issue software as well as users downloading such browsers for free from various software manufacturers, the Metaframe program evolved to permit remote browser-based web access, with the ICA client being replaced by the use of a resident client browser in the PC.

The concept of providing multiple virtual machines is also provided through "Windows Terminal Services" (WTS) software currently available from the Microsoft Corporation ("Windows" is a trademark of the Microsoft Corporation) for Windows NT 4 and Windows 2000 server operating systems, with client-server communication of screen shots, keystrokes and mouse clicks being carried to and from WTS using "RDP ('Remote Desktop Protocol' defined by Microsoft Corporation and based on the ANSI T.128 standard)", rather than an "ICA" protocol. Again, WTS, like the Metaframe program, still carries a considerable processing burden.

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Unfortunately, with this ASP-based approach, the client PC did not appear as if it were connected to the LAN. As such, while this approach did allow remote application execution, it did not accommodate remote  
5 access of other essential office network-based functionality, such as file sharing and e-mail. Hence, this approach was seen as being rather "one-sided".

The art supplemented this ASP-based approach by  
10 incorporating a VPN (layer 2) connection between the LAN and client PC. This, in turn, provided added client functionality inasmuch as the client PC appeared as though it was on the remote LAN. However, this approach not only proved to be rather inconvenient to use but  
15 also, due to its VPN connectivity and for the reasons set forth above, rather expensive.

Specifically, a VPN server was connected to the LAN and a VPN router (or VPN terminator) was connected to  
20 each client PC, or each client PC used OS-based VPN support, or special client software had to be installed on each PC. The Metaframe program or WTS executed on the server which provided access, through a client browser or a special client application program, to a server-hosted  
25 virtual application session. By virtue of the VPN connection, the user at the client PC could remotely execute server-hosted thin-client applications, with the client PC appearing as if it were directly connected to

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the LAN. Unfortunately, this approach, being hampered by the constraints of the Metaframe software or WTS, only accommodated thin-client applications through the browser, and hence was just as "one sided". No other  
5 network functionality, such as e-mail or shared file access, was accommodated through the browser; hence, this approach proved somewhat inconvenient to use. Moreover, the high cost of the associated VPN client-site and office-site servers principally dissuaded many small to  
10 medium size organizations from using this approach.

To off-load some of the processing burden from the LAN server running WTS, a two-tier approach recently appeared in the art through which a specialized  
15 processing system was inserted between the server and a WAN connection. This processor converted RDP packets associated with WTS into AIP packets (AIP is a proprietary protocol owned by Tarantella Inc. of Santa Cruz, California) or to some other less  
20 bandwidth-intensive protocol and conducted client application communication (screen shots, keystrokes and mouse clicks) with the far-end client PC through either of the latter protocols. ICA provides similar bandwidth conserving functionality. Alternatively, communication  
25 in native RDP may be used instead. In any event, the client PC interacted with the processing system through either a specialized client application program or a web browser executing an appropriate JAVA applet ("JAVA" is a

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trademark of Sun Microsystems, Inc. of Palo Alto, California). While this scheme relieved some of the load on the server, it still suffered the same deficiency as an ASP approach: it was not integrated and thus failed to provide through one single user interface, such as a browser, all the functionality which that user would have if his(her) client PC were directly connected to his(her) office LAN.

10           In view of the increasing costs of software acquisition, client installation and maintenance of client application programs, internally centralized ASP-based remote application hosting may well become an attractive alternative for business users.

15           However, adequate security remains a concern, particularly for small to medium size businesses that seek to implement an ASP-approach using the Win 2000 O/S or similar system. In that regard, WTS provides  
20           cryptography, though at a 168-bit level, through use of a symmetric key. While each RDP message from a network server to a remote client is sufficiently encrypted by WTS to preclude its brute-force cryptanalysis, shared symmetric keys are vulnerable to third party discovery  
25           for the simple reason that the secret key has to be distributed to the parties using it, and thus can be obtained by a malicious party. Since the Windows 2000 WTS approach does not involve the use of certificates, it



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is vulnerable to "man-in-the-middle" attacks from malicious parties that have obtained the symmetric key. In symmetric-key cryptography, both sides, here being the remote client PC and the server, utilize the same key.

5 As such, if a third-party interloper, a so-called "man in the middle" that had previously obtained the symmetric key, were to intercept communications, that party through its computer, could pose as the server to the client machine, and as the client to the server machine.

10 However, that party would thus be privy to all communications attempted between the client and the server, and thus have access to information that could be highly proprietary. That party could readily decrypt each message it received from one end and then alter the  
15 message contents as it saw fit, and transmit a modified message to the other end, thus potentially causing considerable mischief. Since WTS provides no effective protection to so-called "man in the middle" attacks, inasmuch as its symmetric key scheme does not involve the  
20 use of certificates and public keys cryptography, use of WTS under the WIN 2000 O/S is still not viewed by many organizations as offering a sufficiently attractive or secure solution to properly support such centralized thin-client application program hosting.

25

Additionally, network faults can and do occur. However, we believe that conventional network management schemes, as conventionally taught in the art, would be

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rather problematic when used with an office LAN that supports web-based remote user connectivity, and particularly so if network maintenance and management responsibility over that LAN is to be out-sourced, for reasons of economy -- as would exist in many organizations -- to a third-party vendor. Remote network management, through a centralized location, would be cost-effective provided the scheme chosen to do so could simultaneously monitor and manage a relatively large number of different LANs likely spread over a wide geographic area.

In particular, for some time, network management has been provided through use of the simplified network management protocol (SNMP). Through this protocol, network routers and other network equipment residing on a network could receive configuration information from and report internal alarm conditions to an SNMP management station connected to that network. In that regard, if a fault occurred within, e.g., a router, then that device could send an SNMP message to its management station in order to report that fault. Based on the specific information conveyed, a technician or other field-service personnel could diagnose, repair or replace that particular router, thus eliminating the fault and restoring the network to proper operation. Unfortunately, SNMP has historically provided inadequate security for its reporting messages.

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Moreover, in using relatively complex network equipment, it would often be rather helpful, whenever that equipment reports a fault, to establish an interactive session with that equipment and, through that session, download a  
5 piece of diagnostic software to that equipment and instruct that equipment to execute it and then report back the results, and based on those results, download and execute other software and so forth in an effort to fully diagnose and correct that fault. Unfortunately,  
10 SNMP, given its reliance on user datagram protocol (UDP) messaging, could not meet this need. In that regard, SNMP was primarily intended to handle relatively simple query-response type interactions between network devices and SNMP management stations. As such, SNMP is not  
15 conversational in nature and is also not session-oriented. Further, SNMP does not readily scale upward inasmuch as necessary hardware and other network infrastructure that would support its scalability, particularly with proper security, does not appear to  
20 commercially exist as yet. In that regard, large SNMP networks are typically partitioned in a predefined manner into much smaller sections through use of a separate corresponding SNMP management station assigned to each section. UDP SNMP messages from these sections are then  
25 often simply coalesced together, through higher level SNMP management devices, to generate a network status report. Thus, readily supporting large numbers of network devices using SNMP management tends to be

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cumbersome and expensive. Also, present SNMP-based schemes are readily susceptible to third-party intrusion.

While use of SNMP may be satisfactory for a  
5 single, well-defined LAN, even a large relatively static  
LAN with a known architecture, SNMP can not accommodate  
simultaneous centralized network management of large  
numbers of diverse LANs. In that regard, a single  
integrated SNMP network spread across all the LANs would  
10 be extremely difficult to configure and maintain, and  
quite costly to implement. Furthermore, if network  
support is out-sourced to a third-party vendor --  
particularly involving separate LANs existing over a  
large, geographically dispersed area, then the Internet  
15 becomes an ideal vehicle to connect a centralized  
management site at the vendor to each of these networks.  
Unfortunately, the weak security of SNMP messaging does  
not lend itself to carriage over a publicly accessible  
network, such as the Internet; thus, frustrating any  
20 provision of centralized, simultaneous out-sourced  
management of large numbers of remote LANs.

Therefore, a need exists in the art for a  
technique, specifically apparatus and methods for use  
25 therein, that provides secure, but integrated network  
functionality through a remote WAN connection between a  
remote client PC and a server based on an office LAN.  
Such a technique should provide all network

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functionality, including, e.g., thin-client application program hosting, file sharing and e-mail, through a single, commonly available user interface, such as a web browser, as if that client PC were connected directly to the LAN. The security should be such as to substantially eliminate potential "man in the middle" attacks or other such third-party intrusions. Furthermore, through such a technique, the client PC should appear as if it were directly connected to the LAN.

10

Furthermore, such a technique should permit centralized, simultaneous and remote management of large numbers of LANs in a manner that is highly secure to a level sufficient to permit network management messages to be carried over the Internet (or other publicly accessible network), session-oriented and readily scalable.

15

While such a technique could utilize a VPN connection, it should function with preferably far less costly alternatives, such as interacting directly with transport schemes such as DSL (digital subscriber line) or other relatively low-cost, high-speed digital access modalities. Also, such a technique should be remotely administered and supported, particularly when employed in those organizations which can not afford to maintain adequate in-house computer support capabilities.

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Such a technique, were it to exist, would likely be very attractive to many organizations, including small and medium sized businesses: (a) to permit effective, readily-scalable but highly secure, internal ASP-based (centralized) thin-client application program hosting for remote client connectivity, with resulting cost savings to those organizations in terms of application procurement through centralized administration and maintenance of those application programs as well as centralized and remote network monitoring and management, and (b) through its use, to yield increased efficiency and productivity by providing remote access for individual users to all their office network-based functionality.

#### SUMMARY OF THE INVENTION

Advantageously, our present invention satisfies this need and overcomes the deficiencies in the art by providing a front-end, in the form of a service enablement platform (SEP), to a LAN-connected office server(s) for implementing secure, remote web-based access, through a WAN-connected user browser, for a user situated at a remote client computer (e.g., remote laptop PC). Through the SEP, the remote user is provided with essentially, if not completely, the same network-based office functionality implemented by the

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office server as if the remote computer were directly connected to that LAN.

In accordance with our inventive teachings, the  
5 SEP is situated between the LAN and the WAN-connected  
user. In use, the SEP acts both as a bridge between the  
remote user and his(her) office applications and as a  
protocol translator to enable bi-directional, web-based,  
real-time communication to occur between the user browser  
10 and each of these office applications. In that regard,  
the SEP provides bi-directional protocol translation to  
exchange necessary information (data and user  
interactions) between, on the one hand,  
application-specific protocols, such as MS-RDP, IMAP4  
15 (Internet Mail Access Protocol version 4) or MS-Net SMB  
(Server Message Block), to communicate with office-based  
client application, e-mail and file servers; and, on the  
other hand, HTML, in conjunction with HTTP, as required  
by the user browser or some other protocol, e.g., AIP or  
20 the like, used by an applet within the browser.

The SEP establishes a LAN connection for the  
remote user that, as far as that user is concerned,  
places the remote PC directly on the LAN. By virtue of  
25 such a connection, the remote user can, e.g.: (a) send  
and receive e-mail through the office e-mail server and  
manipulate his(her) e-mail stored thereon, (b) access,  
through the office file server, all his(her) and other

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shared files stored on and accessible through the LAN as well as transfer files, (c) remotely execute, through the thin-client application server any of his(her) hosted client application programs stored thereon, with  
5 real-time results of each of these operations being displayed in HTML form on the user browser.

Specifically, the SEP includes a separate client application module for each basic office function:  
10 file sharing, e-mail and thin-client application hosting. Each such module accepts as input, in one direction, user interaction data, in the form of URI/URL selection, form input, etc., user mouse clicks and keystrokes provided in HTML form (or in an intermediate transmission protocol,  
15 such as AIP), and generates a message, in the appropriate application protocol, containing this data to a corresponding office application. Each such module also operates in the reverse direction by accepting output information, such as a screen shot or data list, produced  
20 by its corresponding office application and converting that information, from its application protocol, into a graphical HTML page (or in the intermediate transmission protocol) for transmission to and rendering as a web page by the user browser. Thus, each of these modules acts  
25 both as a bridge between the user and a specific one of his(her) office applications and as a protocol translator to enable bi-directional, web-based, real-time



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communication to occur between the user browser and that particular office application.

Furthermore, since remote user access to the SEP is provided on an authenticated basis, through use of a unique, pre-defined and pre-stored certificate, rather than through use of a symmetric key, the present invention is generally not as susceptible to third-party intrusion through so-called "man in the middle" attacks.

Additionally, the SEP continually monitors operational status of itself including its network (LAN and WAN) connections, LAN-connected servers including, for example, each of the hosted office application servers, and/or any group thereof. In the event of a detected fault or failure condition in any monitored entity, the SEP generates a corresponding alarm and reports it, through a web-based connection, to a centralized administrative web site (referred to herein as a "Customer Care Center" (CCC)) to implement remote network monitoring and management functionality. This functionality is implemented through converting data content, including alarm information, from a native format into HTTP-based messaging with the latter being used for web transport and converting that content, once received at the CCC, into an appropriate format for storage thereat. Advantageously, this web-based reporting technique readily allows a large number of

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5       separate LANs that are dispersed over a very wide geographic area to be readily monitored and managed through the CCC. Moreover, the number of such managed networks can be easily scaled upward, as needed, by, for the most part, simply and correspondingly expanding processing and storage capacity of the CCC to handle the anticipated load.

10                By virtue of using centralized network management, a customized configuration profile that defines a network and operational environment, at a customer site, in which the SEP will function can be predefined and centrally stored at the CCC. Once the SEP is installed at that site, the profile can simply be  
15       downloaded from the CCC to the SEP, thereby significantly simplifying SEP deployment. Furthermore, an individual stationed at the CCC can access the stored profile stored on the CCC for any SEP then in use, modify that profile, as needed, such as to reflect changes in, e.g., network  
20       topology or addresses, and then download a modified version of that profile to that particular SEP to update its stored profile. Moreover, should the environment for any SEP change and necessitate that changes be made to the profile then residing at that SEP itself, a copy of a  
25       resulting changed profile can be uploaded from that SEP to the CCC for storage and subsequent use thereat.

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Moreover, during initial installation of the SEP at any customer site, the SEP, after being connected to analog (dial-up) and broadband WAN connections, will dial the CCC and establish a management session with it, through use of a predefined default profile that provides access information to the CCC, in order to obtain appropriate customer WAN login parameters therefrom. The SEP will identify itself to the CCC by providing its hardware media access code (MAC) address and will authenticate itself using HTTP authentication.

Specifically, the SEP will identify itself via its MAC address to the CCC. The CCC will issue a challenge value to the SEP. The SEP will encrypt the challenge value using its private key (of the public key/private key pair stored within the SEP) and respond with the encrypted value. In turn, the CCC will decrypt the response from the SEP. If a resulting value matches the challenge value, the CCC will then consider the SEP to be successfully authenticated. Once a management session has been established with the CCC, the CCC will send the SEP appropriate login and password for a customer WAN account which that the SEP is to use. On receipt of the customer's WAN account information from the CCC, the SEP will tear down its existing analog call to the WAN in order to minimize the length of these initial calls. The SEP will then establish a broadband connection to the WAN service provider using the customer's WAN account information. Once a WAN login succeeds, the SEP will

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continue with its previous management session, though secured through SSL, with the CCC. The SEP will then interact with the CCC and obtain a valid client certificate from the CCC. Future interactions between  
5 the CCC and SEP will use the client certificate to authenticate this SEP in lieu of the previously-used challenge/response mechanism.

In addition to obtaining its client certificate  
10 from the CCC during a remainder of the management session, the SEP will also download its customized profile from the CCC. After successfully obtaining this profile, the SEP will terminate the SSL session between itself and the CCC, reset itself, and then re-initialize  
15 itself using the customized profile to correctly configure its various constituent hardware components and software modules to its current environment. Once correct information identifying the customer is then entered by an administrator at the SEP -- with the  
20 information matching that in the customized profile, the SEP will enter a fully operational mode and accordingly will send an appropriate management message to the CCC to indicate that the SEP is then fully operational.

25 In accordance with a feature of our invention, while the principal office-based applications are file sharing, e-mail and thin-client application program hosting, our invention can readily and easily accommodate

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web-based, secure, remote user access to other additional office-based applications by merely incorporating a corresponding client application module for each such additional office application to provide required  
5 bi-directional, real-time protocol translation for both incoming user interaction data to that office application and output data generated by that office application.

BRIEF DESCRIPTION OF THE DRAWINGS

10

The teachings of the present invention can be readily understood by considering the following detailed description in conjunction with the accompanying drawings, in which:

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FIG. 1 depicts an overall high-level block diagram of a relatively simple and illustrative networked apparatus that embodies the teachings of our present invention and which would be typically used in  
20 conjunction with a relatively small office;

FIG. 2 depicts a high-level block diagram of service enablement platform (SEP) 200, which is used to implement our present invention and as shown in FIG. 1;

25

FIG. 3A depicts a high-level block diagram of software 300 that executes within SEP 200 shown in FIG. 2;

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FIG. 3B depicts principal message paths through software 300 shown in FIG. 3A for passing communication between LAN and WAN connections and through SEP 200, as necessary, for implementing our present invention;

5

FIG. 4 depicts a high-level block diagram of virtual office server software 400, executing within the SEP 200 shown in FIG. 2, for implementing our present invention;

10

FIG. 5 depicts a block diagram of file sharing application module 420 that forms a part of software 400 shown in FIG. 4;

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FIG. 6 depicts state diagram 600 for state machine 522 shown in FIG. 5;

20

FIG. 7 depicts illustrative inter-process communication 700 that involves file sharing application module 420, operative in conjunction with file server 78 (shown in FIG. 1), for obtaining and remotely displaying files for a given user;

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FIG. 8 depicts a block diagram of e-mail application module 430 that forms a part of software 400 shown in FIG. 4;

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FIG. 9 depicts state diagram 900 for state machine 822 shown in FIG. 8;

FIG. 10 depicts illustrative inter-process communication that involves e-mail application module 430, operative in conjunction with e-mail server 76 (shown in FIG. 1), for retrieving and remotely displaying a list of incoming e-mail messages for a given user;

FIG. 11 depicts a block diagram of thin-client application module 440 that forms a part of software 400 shown in FIG. 4;

FIG. 12A depicts state diagram 1200 for state machine 1122 shown in FIG. 11 for those states associated with a user-initiated interaction with thin-client application server 72, shown in FIG. 1, to start a client application session;

FIG. 12B depicts state diagram 1250 for state machine 1122 shown in FIG. 11 for those states associated with an interaction initiated by client application server 72, shown in FIG. 1, specifically to update a display screen on user browser 15 for an executing thin-client application program;

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FIG. 13 depicts illustrative inter-process communication that involves thin-client application module 440, operative in conjunction with client application server 72 (shown in FIG. 1), for remotely  
5 executing a thin-client application program at server 72 and displaying graphical results therefrom on user browser 15;

FIG. 14 shows a highly-simplified, high-level  
10 block diagram of administrative web site 20 shown in FIG. 1;

FIG. 15 depicts actual screen shot 1500 of a typical graphical display screen rendered at user  
15 browser 15, shown in FIG. 1, through which a remote user logs onto his(her) virtual office capability provided by the present invention;

FIG. 16 depicts actual screen shot 1600 of a  
20 typical display screen rendered at user browser 15, shown in FIG. 1, for permitting a remote user, through the file sharing capability of the present invention, to remotely access and manipulate his(her) files residing on file server 78;

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FIG. 17 depicts actual screen shot 1700 of a typical display screen rendered at user browser 15, shown in FIG. 1, through which a remote user, through the



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e-mail capability of the present invention, can remotely access his(her) e-mail stored on e-mail server 76 as well as send outgoing e-mail to that server;

5                   FIG. 18 depicts actual screen shot 1800 of a typical display screen rendered at user browser 15, shown in FIG. 1, through which a remote user, through thin-client application program support capability of the present invention, can remotely execute his(her) client  
10 application programs hosted on client application server 72;

                  FIG. 19 depicts software 1900, organized by protocol layers, that implements our inventive remote  
15 monitoring and management (RMM) capability, through web site 20, for LAN 65 connected to SEP 200, all of which is shown in FIG. 1;

                  FIG. 20 depicts a very high-level block diagram  
20 of software 2000, including service monitoring agent 2010 and associated routines 2050, that executes within SEP 200 for implementing a LAN-based portion of the RMM capability;

25                   FIG. 21 depicts a detailed block diagram of software 2000;

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FIG. 22 depicts a detailed block diagram of software 1950, shown in FIG. 19, which interacts with software 2000 and executes within web site 20;

5           FIG. 23 depicts inter-process communication that occurs, in response to a request arising within SEP 200, such as during initial installation of the SEP, for obtaining a configuration profile from web site 20 and storing that profile within the SEP;

10           FIG. 24 depicts inter-process communication that occurs, in response to a request arising within web site 20, for downloading a stored configuration profile from SEP 200 into web site 20;

15           FIG. 25 depicts inter-process communication that occurs, in response to an alarm generated within SEP 200, for providing alarm information from the SEP to web site 20; and

20           FIG. 26 depicts inter-process communication that occurs, in response to a request arising within web site 20, for downloading a profile from that web site to SEP 200 and writing that profile within the SEP.

25           To facilitate understanding, identical reference numerals have been used, where possible, to

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designate identical elements that are common to the figures.

DETAILED DESCRIPTION

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After considering the following description, those skilled in the art will clearly realize that the teachings of our present invention can be utilized in any of a wide number of different client-server networked processing architectures that support remote access from a client PC to a server located on an office LAN.

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In essence, our present invention supports remote, secure, web-based user access to network-supported and hosted office processing functions, including client application programs, e-mail and file sharing, to a remotely located user with the same capabilities and essentially the same ease of use as if his(her) computer were directly connected to an office network rather than through a wide area network (WAN) or other remote connection; hence, providing that user with a so-called "virtual office". Advantageously, our inventive apparatus effectively implements a front-end, illustratively referred to as a service enablement platform (SEP), to the office server, regardless of whether that office server is implemented by a single machine (computer) or multiple machines, and regardless of whether those machines are co-located or not, as long

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as they are interconnected to the apparatus through an appropriate network. If the office server is implemented by multiple inter-networked machines -- as is often the case in medium or large sized organizations, each of these machines can handle one or more specific office processing tasks, e.g., client application program hosting, e-mail serving and/or file serving.

Alternatively, for small organizations with limited processing equipment, either our inventive apparatus itself, through its internal processing capability, can implement all these tasks or can serve as a front-end to a single separate machine (computer) which does so.

Additionally, an important aspect of our present invention provides, through WAN connectivity, centralized, simultaneous, web-based remote monitoring and management (RMM) of a relatively large number of multiple office networks in a session-oriented, secure and readily scalable manner.

Advantageously, our inventive RMM technique has been implemented in connection with "virtual office" functionality as described in co-pending United States patent application titled "APPARATUS AND ACCOMPANYING METHODS FOR PROVIDING, THROUGH A CENTRALIZED SERVER SITE, A SECURE, COST-EFFECTIVE, WEB-ENABLED, INTEGRATED VIRTUAL OFFICE ENVIRONMENT REMOTELY ACCESSIBLE THROUGH A NETWORK-CONNECTED WEB BROWSER", filed on March 14, 2001

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and assigned serial number 09/808,404, which is co-owned by the present assignee hereof and is incorporated by reference herein.

5                   For the sake of simplicity, we will describe both the "virtual office" functionality and the RMM technique for use in a small office environment where either the SEP serves as a front-end to a single machine, situated at an office location and on a single LAN, that  
10 collectively implements all the necessary office processing tasks, or additionally implements all those tasks itself. Furthermore, although the SEP can readily support simultaneous access by multiple remotely located clients, again for simplicity, we will describe it in the  
15 context of use with only one such client at a time. Clearly, based on the ensuing description, those skilled in the art can readily appreciate how the SEP can simultaneously accommodate multiple clients and can be scaled upward to simultaneously handle relatively large  
20 numbers of such clients, and also how the RMM technique can be easily scaled upward to simultaneously handle multiple different LANs.

25                   FIG. 1 depicts an overall high-level block diagram of illustrative networked environment 5 that embodies the teachings of our present invention and is particularly suited for use in conjunction with a small office.

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As shown, this environment includes remote client 10, that is typically a personal computer (PC) generally a laptop, connected through wide area network (WAN) 30, to office server 40 situated at an office site. WAN 30 can be implemented by a publicly accessible network, such as the Internet, or a private network. Connectivity to the WAN is provided through any relatively high-speed (broadband) access modality such as, e.g., digital subscriber line (DSL), cable modem, integrated service digital network (ISDN), fractional T1 or even a T1 line. Alternatively, remote dial-up analog modem access can be used instead, though end-to-end transport delays, in view of a relatively slow communication speed provided by such a modem, may markedly slow system response as perceived by a user situated at PC 10.

Our invention advantageously utilizes web-based access to office applications, with those applications being remotely hosted by virtual office server 40 and encrypted communication provided through conventional secure sockets layer (SSL) capability supported within the browser. As such, client 10 contains conventional user browser 15. Advantageously, since all the office applications are hosted remotely, there is no need to install, configure or maintain any user application programs, other than a web browser, on remote client 10;

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thereby, dramatically reducing cost of ownership of the client PC.

Virtual office server 40 contains conventional  
5 broadband WAN interface 53, firewall/router 57, service enablement platform (SEP) 200, and server 70.

Interface 53 is conventional in nature and provides high-speed network access. It can take the form of, e.g., a cable modem, a DSL interface, an ISDN terminal  
10 adapter or a fractional/full T1 interface. The specific modality of peered-network access used by both client PC 10 and interface 53 is not critical provided that the chosen modality can support sufficiently high access speeds between the remote client and server 40.

15 Firewall/router 57 is conventional in nature and attempts to isolate server 40 from unauthorized network-based attacks as well as provide outgoing and incoming network routing capability to and from WAN 30. While interface 53 and firewall/router 57 are both shown as  
20 being external to the SEP, interface 53 can be located internal to the SEP as, to the extent needed, can firewall/router 57. From a network perspective, SEP 200 is situated between WAN 30 (via broadband interface 53 and firewall/router 57) and local area network (LAN) 65.

25 In accordance with our inventive teachings and as described in considerable detail below, SEP 200 provides a front end to server 70 for implementing

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secure, remote, web-based access, through browser 15, by a user situated at client 10 to the network-based office functionality implemented by server 70 and to the same extent as if client PC 10 were directly connected to LAN 65. Server 70 resides on LAN 65 to collectively implement, through separate internal LAN accessible application servers, various office processing applications (tasks) including, through client applications server 72, thin-client hosted application programs; through web-enabled application server 74, remotely-hosted web-enabled thin-client application programs; through e-mail server 76, e-mail messaging; and, through file server 78, shared file access. Each of these servers is conventional, with E-mail server 76 being implemented, for example, by a Microsoft Exchange Server ("Microsoft Exchange" is a trademark of Microsoft Corporation of Redmond, Washington). As noted, in small offices, server 70 is typically implemented by a single server computer. Alternatively, rather than using two separate physical computers, server 70 and SEP 200 can be collectively implemented, as indicated by dot-dashed line 60, on one single physical computer -- with the necessary processing needed to implement server 70 being provided by SEP 200. However, to facilitate understanding, we will depict SEP 200, in terms of its functionality, separate from that of server 70 or any of the hosted applications and servers executing thereon.



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Furthermore, during initial configuration of office server 40, SEP 200 establishes a dial-up connection, as symbolized by line 59, via WAN 30, to administrative web site 20 (also referred to as "CCC" -- customer care center -- which specifically is a web site operated by Netilla Networks Inc., which is the present assignee thereof) through which a unique X.509 digital certificate is downloaded to and stored on SEP 200, along with other configuration information, such as, e.g., necessary IP addresses. This certificate is used to provide secure conventional, encrypted, authenticated communication that is substantially immune to "man in the middle" attacks. Since the manner through which SEP 200 utilizes the certificate is conventional, as is the use of SSL by browser 15, we will not address these aspects in any detail. Once this certificate and configuration information have been provided over line 59, SEP 200 establishes a web-based (HTTP) connection to web site 20 to complete its set-up procedure. SEP 200, once fully configured and functioning in a network environment, continually monitors the state of its network connections, both to WAN 30 and LAN 65, as well as the state of LAN 65 and the various application servers (whether executing in a separate physical computer or on the same computer that implements SEP 200), and provides associated maintenance and status information back to a server (not shown) associated with web site 20, by establishing a dial-up connection to WAN 30 via line 59,

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for purposes of remote monitoring, problem diagnosis and routine maintenance. Since none of these particular functions is relevant to the present invention, these functions will not be discussed in any further detail.

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Once SEP 200 is fully functioning in its network environment, a user situated at his(her) PC can readily and remotely access his(her) office network-based applications by simply establishing a secure web (HTTPS) connection to a web server implemented on SEP 200. To do so, the user enters, through browser 15, a web address associated with this server. Once the connection is established, a web page, as shown in screen shot 1500 for a typical graphical display depicted in FIG. 15, is downloaded by SEP 200 to the user browser through which, once rendered by the browser, the user then enters his(her) username and password to log on to virtual office capability provided by SEP 200. After the user successfully logs in by entering his(her) username and password in fields 1510 and clicking on "Log In" button 1520, a session begins through which a web page is downloaded by SEP 200, as shown in FIG. 1, and displayed on the browser through which several icons, illustratively tabs, are displayed: "My Files", "My E-mail", "My Apps" and "My Admin" (such as those appearing in screen shots 1600, 1700 and 1800 of the displays shown in FIGs. 16, 17 and 18; all of which are discussed in detail below). The user can then click on

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any of these icons, which, once communicated back to SEP 200, will cause the SEP 200 to launch the associated office application (or administrative function for the "My Admin" tab), generate an HTML file for a graphical display produced by that application, and then download the HTML file to browser 15, for local rendering thereat. During the web session, browser 15 communicates user form input and URI (uniform resource identifier)/URL (uniform resource locator) selection via HTTP requests to SEP 200 which processes this input and provides an appropriate display back to the browser. In addition, for application support, an efficient protocol such as AIP (or the like) is used to transfer user keystrokes and mouse clicks from a window on the remote PC representing an application executing on a remote server to SEP 200, which then relays that user interaction data to the application server via RDP for processing. Note that RDP itself could have been used between the remote browser and SEP 200, but use of AIP or a similar protocol provides more efficient bandwidth utilization than does RDP. The user can readily move between one remote office application to the next by simply clicking on the associated icon.

In doing so, SEP 200 (see FIG. 1) establishes a LAN connection for the remote user that, as far as that user is concerned, places remote client 10 directly on the LAN. By virtue of such a connection, the remote user

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can, e.g.: (a) send and receive e-mail through server 76 and manipulate his(her) e-mail stored thereon, (b) access, through file server 78, all his(her) files, as well as other shared files, stored on and accessible through LAN 65, (c) remotely execute, through application server 72, any of his(her) thin-client applications hosted thereon, as well as through server 74 remotely execute any of his(her) thin-client web-based applications hosted there, with real-time results of each of these operations being displayed in HTML form on browser 15. Application server 72 receives user mouse clicks and keystroke data and provides user screen shot displays through use of Microsoft RDP (remote desktop protocol). Web-enabled application server 74 communicates client application information using HTTP. E-mail server 76 utilizes a conventional IMAP4 protocol; while file server 78 communicates user information using Microsoft MS-NET Simplified Message Block (SMB) data (to implement Microsoft NET-BIOS functionality). Note, that while SMB and IMAP4 were shown here as examples, other protocols such as Novell Netware and the POP3 (Post Office Protocol 3) are usable as well.

In essence, as the reader can appreciate, SEP 200 acts both as a bridge between the user and his(her) office applications and as a protocol translator to enable bi-directional, web-based, real-time communication to occur between user browser 15 and each

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of these office applications. In that regard, the SEP provides bi-directional protocol translation to exchange necessary information (data and user interactions) between, on the one hand, MS-RDP, IMAP4 or MS-Net SMB to communicate with office application servers 72, 76 or 78, respectively; and, on the other hand, HTML and HTTP as required by user browser 15 for non-thin-client applications, and AIP, or a similar protocol, for thin-client control information, or for thin-client user interaction data transfer (i.e., mouse clicks, keystrokes, control data).

FIG. 14 depicts a highly simplified, high-level block diagram of administrative web site (CCC) 20.

As shown, site 20 is formed of a front-end portion that provides homepage and user interface web pages, database 1420 and a back-end portion having interfaces 1430 and 1440.

Front-end portion 1410 provides a home page and user interface which permits users 1460 to access this site. These users include appropriate Netilla Networks Inc. technical personnel (Netilla Networks Inc. is the present assignee hereof; hereinafter referred to as "Netilla") as well authorized third-parties, such as Netilla partners (e.g., resellers), system integrators and installers, to log onto site 20, on a secure, though

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restricted basis (depending on the person seeking access). Once appropriate username and password information is entered, each such user gains access for purposes of configuring and determining operational status of any SEP for which (s)he is then providing technical assistance or is responsible. In addition, members of the public can access certain web pages associated with site 20 that provide general information regarding the services currently offered by Netilla and other related information posted on that site.

Database 1420, which interacts with both the front- and back-end portions of site 20, stores information for each SEP then in service, alarm reports generated by each such SEP and other related status as provided by that SEP, configuration and maintenance information for that SEP, as well as information (such as user name and password) to permit appropriate access to certain secure areas of the site by Netilla technical personnel as well as each authorized third-party user, i.e., resellers, installers and system integrators. Interface 1430, through service monitoring software 1950, communicates with individual SEPs (of which, for simplicity, only one SEP 200 is shown in FIG. 1) in order to permit Netilla technical personnel or an authorized third-party to change configuration information, e.g., a configuration profile, stored on a particular SEP and to instruct web site 20 to send such changed information to this particular SEP, as well as to receive and log alarm information from each SEP and to

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download and install appropriate software  
upgrades/updates either on that SEP itself or on any  
server then residing on an associated LAN connected to  
that SEP. Within site 20, database 1420 stores SEP  
5 configuration information and alarm logs.

Interface 1440, utilizing information stored within  
database 1420, communicates with conventional back-end  
business applications, such as accounting and billing  
systems 1450, to, among other aspects, establish a new  
10 account for a SEP to be or then being installed, modify  
an existing account and periodically bill an appropriate  
party, such as a third-party reseller, for use of each  
SEP for which that party is responsible.

15 FIG. 2 depicts a high-level block diagram of  
service enablement platform (SEP) 200. Though SEP 200 is  
depicted with a particular and rather simple  
architecture, it can alternatively be implemented by  
nearly any commercially available, general-purpose  
20 personal computer, workstation or server, providing it is  
equipped with two different and distinct Ethernet ports  
and a modem.

As shown, SEP 200 contains Ethernet I/F  
25 ports 220 and 250 (also referred to as Ethernet ports 1  
and 2), V.90 Fax modem 230, and microprocessor 260, all  
interconnected by local bus 240. Microprocessor 260,  
which is illustratively any conventional Intel Pentium

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grade processor or equivalent (having a clock speed of, e.g., 300 MHz or higher) (Pentium is a trademark of Intel Corporation of Santa Clara, California), is itself connected, through bus 267, to memory 270 and via bus 263 to hard drive 280. Memory 270 is illustratively synchronous dynamic random access memory (SDRAM). Hard drive 280 stores program 300 and X.509 certificate 284. During operation of SEP 200, segments of program 300, to the extent needed, are copied from hard drive 280 into memory 270 from which those segments are executed. Memory 270, being volatile, also stores temporary data, as required during program execution.

Ethernet ports 1 and 2 permit the SEP to be situated in series, via LAN connection 65, between office server 70 (see FIG. 1), and, via an Ethernet connection symbolized by line 62, to a broadband connection to the WAN, via interface 53 (through, e.g., firewall/router 57). As such, SEP 200 can intercept incoming network messages incoming from WAN 30, perform required protocol conversion and IP address translation on each such message and route that message to a correct office application server on LAN 65, and provide the opposite functionality in a reverse direction for outgoing messages.

Fax modem 230 provides analog dial-up connectivity over line 59 for use, as described above,



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during installation of SEP 200; for communicating monitoring and status information back to administrative web site 20, and as a back-up data connection in the event the broadband connection fails. The fax capability  
5 of the modem is not used by SEP 200 unless a specific hosted user (thin-client) application program requests it.

FIG. 3A depicts a high-level block diagram of  
10 software 300 that executes within SEP 200 shown in FIG. 2.

This software is composed of three basic components: operating system (O/S) and related  
15 modules 305, virtual office software 400 and management module 2000.

Component 305 is formed of a basic O/S kernel 310, illustratively a conventional Linux O/S, with  
20 specific additional and conventional Linux modules to implement necessary network and web-based processing, and device operation. These modules include network address translation (NAT) module 320, IP routing module 330, Open  
SSL module 340, web server 350 (which is currently  
25 available under the name "Apache web server"), send mail module 360, TCP/IP processing module 370, PPP processing module 380 and device drivers 390. Software 300 includes, as its other component, virtual office

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software 400 that communicates, as symbolized by  
line 357, through Apache web server 350. Though a Linux  
O/S kernel is used, O/S 310 could just as easily be  
implemented using nearly any other PC or server-based  
5 operating system, such as a UNIX or Microsoft Windows  
operating system -- though, of course, the modules would  
need to be compatible with the chosen O/S.

NAT module 320 is conventional in nature and  
10 translates network, specifically IP, addresses as  
requested by O/S kernel 310. In particular, for incoming  
messages from the WAN, depending on their port  
designations -- which identifies a particular office  
application server and program on server 70 for which the  
15 message is intended, module 320 translates the address of  
each such message from the IP address of the SEP to an IP  
address associated with that particular server. The port  
designation remains to define the particular server for  
that message. Similarly, though in a reverse direction,  
20 NAT 320 translates each outgoing message, based on its  
port address, from each one of the servers and destined  
to the remote client PC from the private IP address of  
the server to the public IP address of the SEP along with  
the corresponding port designation.

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IP routing module 330 provides a routing table  
that provides IP routing information to O/S kernel 310.  
This routing table is established during initial

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configuration of the SEP from routing information provided from administrative web site 20 (see FIG. 1). It can, alternatively, be updated via conventional dynamic routing protocols such as RIP, OSPF, etc.

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Open SSL module 340, as shown in FIG. 3A, provides conventional SSL processing -- though in a Linux environment, including message encryption/decryption, using X.509 certificate 284. This certificate once downloaded during initial configuration of the SEP, is then accessed, as symbolized by line 343, by SSL process 340. The Apache web server uses the Open SSL module for secure traffic received over TCP port number 443.

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Module 350 is a conventional web server, though again suited for use in a Linux environment, and provides a web-based portal through which virtual office software 400 communicates, over a WAN connection, with user browser 15 and receives user interaction data (mouse clicks and keystrokes therefrom) and provides screen shots thereto for local display on remote PC 10.

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Sendmail module 360 (also known as "Qmail" for use with the Linux O/S) is conventional and is employed if SEP 200 is used without an external e-mail server, such as e-mail server 76 shown in FIG. 1. Module 360

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implements message transmission through use of SMTP  
(simplified mail transport protocol).

5 TCP/IP processing module 370 and PPP processing  
module 380, shown in FIG. 3A, are conventional in nature  
and correspondingly implement a well-known TCP/IP stack  
(with packet assembly and disassembly) and provide  
point-to-point protocol (PPP) packet processing for use  
with packet transmission employing the PPP protocol over  
10 dial-up WAN link 59.

Device drivers module 390 (see FIG. 3A)  
comprises a set of conventional device drivers operating  
under control of O/S kernel 310 to control two Ethernet  
15 ports 220 and 250, V.90 fax/modem 230 and a local LCD  
display (not shown). Information is communicated between  
device drivers module 390 and Ethernet ports 220 (Port 1)  
and 250 (Port 2), and V.90 Fax Modem 230 as symbolized by  
lines 396, 394 and 398, respectively and, as symbolized  
20 by line 392, between display drivers module 390 and O/S  
kernel 310.

Communication between O/S kernel 310 and  
modules 320, 330, 340, 350, 360, 370, 380 and 390 is  
25 symbolized by lines 325, 335, 347, 353, 365, 375, 385 and  
392, respectively. Inasmuch as modules 320, 330, 340,  
350, 360, 370 and 380 are all conventional and readily

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available Linux components, none of them will not be discussed in any further detail.

Virtual office software 400, operative in  
5 conjunction with web server module 350, forms a core  
software component of our present inventive apparatus.  
In that regard, software 400 (which is discussed in  
detail below) implements real-time, bi-directional  
protocol translation, as described above, to enable the  
10 user situated at remote PC 10 to remotely control,  
execute and interact with any office application hosted  
at server 70 (see FIG. 1). In that regard, through  
appropriate protocol conversion, software 400, as shown  
in FIG. 3A, exchanges necessary information (data and  
15 user interactions) between, on the one hand, MS-RDP,  
IMAP4 or MS-Net SMB to communicate with office  
application servers 72, 76 or 78 (see FIG. 1),  
respectively; and, on the other hand, HTML and HTTP (or  
an intermediate transport protocol, e.g., AIP) as  
20 required by user browser 15 for non-thin-client  
applications, and AIP or a similar protocol for  
thin-client applications -- all as required to support  
centralized hosting of office applications (e.g., user  
application hosting, file serving, and e-mail) but with  
25 user interaction and application display occurring  
remotely at the client computer under the browser.  
Modules 320, 330, 340, 360, 370 and 380, as shown in  
FIG. 3A, all provide necessary network packet processing,

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including address translation, encryption/decryption and  
send mail functionality, ancillary to software 400 but  
necessary to support proper packet communication over a  
WAN connection between it and both remote PC 10 and  
5 individual office applications executing on local  
server 70 (shown in FIG. 1).

Management module 2000 is a transparent  
background (daemon) process, operating in conjunction  
10 with O/S kernel 310, that is responsible for detecting  
fault conditions affecting SEP 200, LAN 65 as well as any  
of the virtual office applications and reporting  
corresponding alarms to administrative web site (CCC) 20,  
as well as to download/upload a configuration profile  
15 from or to the CCC to or from the SEP, receive software  
updates and upgrades from the site 20 for installation  
either at SEP 200 or the appropriate server residing on  
LAN 65. Outgoing messages from management module 2000 to  
site 20 or to the LAN are routed, as symbolized by  
20 lines 313 and 375, via the O/S kernel to TCP/IP  
processing module 370 for appropriate packetizing and  
other related processing. Incoming messages from site 20  
are routed, as symbolized by line 355, directly from  
Apache web server 350 to management module 2000.  
25 Management module 2000 interacts with many of the modules  
shown in component 305; though, for simplicity, only the  
principal interactions involving this module are shown.  
For example, one such interaction that is not shown is

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with IP routing module 330. In the event of a failure in the broadband WAN link as detected by the management module, routing module 330 then changes its routing to utilize dial-up link 59 (see FIG. 1) to reach WAN 30 rather than the broadband connection, until such time as the latter connection is subsequently restored.

FIG. 3B depicts principal message paths through software 300 for passing communication between LAN and WAN connections and through SEP 200.

Given the location of the SEP intermediate between LAN 65 and WAN 30, three basic paths, i.e., paths 402, 404 and 406, exist, all three of which are under the control of O/S kernel 310. Note that paths 404 and 404a are common from the bottom of the figure to a point just below the Apache web server. From that point, path 404 continues through the Apache web server to the virtual office software, while path 404a bypasses the Apache web server and goes directly to the virtual office software.

First, incoming packets from the WAN connection, i.e., originating from remote PC 10 (see FIG. 1) and containing user interaction information relevant to non-thin-client functionality (e.g., user URI/URL selection, forms inputs, etc.) flows, as symbolized by dashed line 404 (also labeled as path "B"

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in FIG. 3B), through Ethernet port 220 (port 1), within the SEP through device drivers module 390, and via the O/S kernel, to TCP/IP processing module 370 for appropriate TCP/IP packet processing, including packet  
5 disassembly. From TCP/IP processing module 370, the resulting information in the disassembled packet is provided by O/S kernel 310, to web server 350, which calls on services of Open SSL module 340 to perform SSL processing on the packet, if necessary; for the Netilla  
10 Virtual Office, all information transfer is protected by SSL. After SSL processing, the HTTP request is extracted and sent to virtual office software 400 for protocol translation into a form suitable for use by a desired office application. Once virtual office software 400 has  
15 appropriately processed the information, by providing suitable protocol conversion, that information flows directly from software 400 to that office application accessible through the LAN if necessary (i.e., if it cannot be handled directly by the virtual office  
20 software). Information (such as the "network neighborhood" for the file sharing application) from the SEP destined to the remote user flows along path 404 but in an opposite direction to that just described so as to provide the opposite functionality.

25 Incoming packets from the WAN connection, i.e., originating from remote PC 10 (see FIG. 1) and containing user interaction information relevant to thin-client



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functionality (e.g., starting of a thin-client application, keystrokes and mouse clicks associated with a thin-client application, etc.) flows, as symbolized by dashed line 404a, through Ethernet port 220 (port 1),  
5 within the SEP through device drivers module 390, and via the O/S kernel, to TCP/IP processing module 370 for appropriate TCP/IP packet processing, including packet disassembly. From TCP/IP processing module 370, the resulting information in the disassembled packet is  
10 provided by O/S kernel 310, to virtual office software 400 via path 404a (paths 404 and 404a are identical except at the very end; path 404 goes to the software 400 via the Apache web server while path 404a goes directly to the virtual office software). Once  
15 virtual office software 400 has appropriately processed the information by providing suitable protocol conversion (including performing SSL operations on the data), that information flows directly from software 400 to that office application accessible through the LAN via  
20 path 402, as described below, if necessary (i.e., if it cannot be handled by the virtual office software directly). Information (such as a thin-client screen update for a particular thin-client application, such as Microsoft Word, for example) from the SEP destined to the  
25 remote user flows along path 404a and then via path 404 but in an opposite direction to that just described so as to provide the opposite functionality.

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Information incoming to the SEP from the LAN and which is ultimately destined to the remote user for non-thin-client applications (e-mail and file sharing) flows as shown by dotted path 402 (also labeled as path "A") within the SEP. This information is first received by Ethernet interface 250 (port 2), which is connected to the LAN, and from there transits through device drivers module 390, O/S kernel 310, TCP/IP processing module 370 (again for packet disassembly), then back through the O/S kernel to virtual office software 400. For non-thin-client data (i.e., data involved with file sharing or e-mail), software 400 generates an appropriate HTML page via an HTTP response containing this information and thereafter provides this page to web server 350. The web server calls on the services of Open SSL module 340 to provide appropriate security functions, and then transmits this page, via an HTTP response, to the remote client PC, specifically user browser 15 for display thereat. The data path from the virtual office software subsequently follows path 404 described previously. Information from the SEP, i.e., originating from the user, to the LAN flows in a reverse direction to that described in order again to provide the opposite functionality.

Information incoming to the SEP from the LAN and which is ultimately destined to the remote user for thin-client applications flows as shown by dotted

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path 402 within the SEP. This information is first received by Ethernet interface 250 (port 2), which is connected to the LAN, and from there transits through device drivers module 390, O/S kernel 310, TCP/IP processing module 370 (again for packet disassembly), then back through the O/S kernel to virtual office software 400. For thin-client data (i.e., data involved with application execution on servers on the LAN), virtual office software 400 performs data protocol conversion if necessary (for example, from RDP to AIP), along with the appropriate image conversions. Software 400 then generates appropriate AIP packets, on which it performs security operations as necessary, and then forwards those packets along path 404a to the remote client PC, specifically user browser 15 for display thereat. Information from the SEP, i.e., originating from the user, to the LAN flows in a reverse direction to that described in order again to provide the opposite functionality.

Note that in the traversals described above, the transference of data is traced through the O/S kernel as much as possible. However, since the O/S kernel is involved in essentially all operations that occurs in the SEP, FIG. 3B only shows those data flows particularly pertinent to the present invention, else showing every single interaction with the O/S kernel would result in overwhelmingly complex data flow diagram with essentially

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little gained from a perspective of understanding. Thus, for example, when the Apache web server hands off data to the virtual office software, the former must use some O/S kernel services to do so. But this does not add to the  
5 understanding and unnecessarily complicates the diagram if one were to show this; therefore, FIG. 3B traces a direct path between the web server software and the virtual office software.

10                   Lastly, information incoming to the SEP through the dial-up connection, such as from administrative web site 20, flows as shown by dot-dashed path 406 (also labeled as path "C"). This information is first received by V.90 fax modem 230, such as from the administrative  
15 web site via the WAN, and from there transits through device drivers module 390, O/S kernel 310 and PPP processing module 380. Once module 380 has provided requisite PPP processing, O/S kernel 310 routes the resulting processed message to TCP/IP processing  
20 module 370 (again for packet disassembly), then back through the O/S kernel to virtual office software 400, via web server 350, for protocol translation into a form suitable for use by a desired office management process or application, and for subsequent routing to the  
25 appropriate office application server, if necessary. Outgoing information from the SEP, i.e., originating from an office management process or application server and destined to, e.g., the administrative web site but

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carried through the dial-up WAN connection flows in a reverse direction to that described in order to provide the opposite functionality. Specifically, for such outgoing information, software 400 first receives the  
5 information from the office management process or application server and then applies this information to web server 350 which, in turn, imparts HTTP processing of this message. The message then transits, via the O/S kernel, to TCP/IP processing module 370 and PPP  
10 processing module 380 prior to be routed, via device drivers 390, to the V.90 fax modem for transmission, via dial-up WAN connection 62, to the user browser. Note that sessions originating from the SEP, such as sessions to the administrative web site from the management  
15 process in the SEP, would follow essentially the same outgoing and incoming paths, except that they would not go through the Apache web server.

FIG. 4 depicts a high-level block diagram of  
20 virtual office server software 400.

As shown, software 400 contains four office application modules: file sharing application module 420, e-mail application module 430, thin-client application  
25 module 440 and administration module 450; along with multiplexor 410.

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In general, each of the modules accepts as input, in one direction, user interaction data, in the form of user URI/URL inputs and forms data provided via HTTP/secure HTTP or in the form of keystrokes, mouse  
5 clicks, etc. encoded via a transport protocol, such as AIP, (optionally secured by SSL) for the thin-client support and generates a message, in an appropriate application protocol, containing this data to a corresponding office application. Each such module also  
10 operates in the reverse direction by accepting output information, such as a screen shot or data list, produced by its corresponding office application and converting that information, from its application protocol, into a graphical HTML page in a secure HTTP response or into a  
15 transport protocol, such as AIP, secured by SSL for thin-client support for transmission to and rendering, as a web page, by the user browser. Thus, each of these modules acts both as a bridge between the user and a specific one of his(her) office applications and as a  
20 protocol translator to enable bi-directional, secure, web-based, real-time communication to occur between user browser 15 and that particular office application.

File-sharing application module 420 (described  
25 in detail below in conjunction with FIGs. 5-7) interacts with a client file handler (specifically a Linux "SAMBA" module which is an open source software component that implements a NET-BIOS Windows Networking client on a

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Linux O/S to interact with Windows based file servers) in order to provide user file information, such as listings of desired directories, and permit the user to copy, move and delete files, as desired.

5

E-mail application module 430 (described in detail below in conjunction with FIGs. 8-10) interacts with a client e-mail handler (specifically an IMAP client) to access and retrieve user e-mail stored on an e-mail server, such as a Microsoft Exchange server, as well as to manipulate stored e-mail residing in the user's e-mail folders (Inbox, Outbox, Sent Mail and the like) on that server. In terms of message reception, module 430 provides a list of received messages, typically with address and truncated content information -- as typically occurs in e-mail clients (such as in Microsoft Outlook e-mail client program; "Microsoft Outlook" is a trademark of the Microsoft Corporation of Redmond, Washington) and, once displayed, permits the user to select, and separately and fully display each message, as desired. This module also permits the user to send outgoing e-mail to and through that server.

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Thin-client application module 440 (described in detail below in conjunction with FIGs. 11-13) interacts, through the remote desktop protocol (RDP), with a client application program (e.g., Microsoft Word, Microsoft Excel or other application program; "Microsoft

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Word" and "Microsoft Excel" are trademarks of the Microsoft Corporation of Redmond, Washington) being hosted on server 70. Module 440 receives user mouse clicks and keystrokes from the user browser, in AIP form, and passes that information, via RDP, to the client application program to control its execution. In return, this module obtains graphical output displays, as screen shots, generated by the client application program and in RDP form, and converts those screen shots into AIP form and then transmits AIP messages, containing the screen shots, back to the user, specifically the user browser for rendering thereat.

Administration module 450 maintains lists of user names and passwords and other information necessary to permit controlled, secure, remote access to the virtual office functionality as well as to properly monitor its ongoing operation. This module interacts through web server 350 and contains a conventional internal database and associated processes (all of which are not shown but well known) to maintain lists (including establishing initial lists and updating them as needed) of authorized user names and passwords, and, based on login information supplied by a user then seeking remote access, determine whether that user is to be permitted to access virtual office functionality and, if so, to enable such access. This module also alerts administrative web site 20 (see FIG. 1) if, as a result



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of its monitoring tasks, it detects any abnormal operation for any of the virtual office functionality. Since this module is not particularly relevant to the present invention, we will not discuss it in any further  
5 detail.

Multiplexor 410 passes each outgoing message from each of the modules destined to the user to web server 350 or directly to TCP/IP module 370 for the  
10 thin-client processing, as well as each incoming message from the user, as received by the web server or directly from the TCP/IP module, to an associated one of the application modules. Communication between each of applications 420, 430, 440 and 450, and multiplexor 410  
15 is symbolized by lines 425, 435, 445 and 455, respectively; while communication between the multiplexor and the web server is symbolized by line 357 and communication between the multiplexor and the TCP/IP module (via the O/S kernel) is symbolized by line 358.

20

FIG. 5 depicts a block diagram of file sharing application module 420 that forms a part of software 400 shown in FIG. 4. As noted above, this module interacts with a client file handler (file server) to provide the  
25 remote user with his(her) file information, such as listings of desired directories, and permit that user to copy, move and/or delete files to which that user has appropriate access.

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Module 420 contains SAMBA component 510, file sharing front end component 520 and HTML pages 530.

SAMBA component 510 is a conventional open  
5 source LINUX component that implements a NET-BIOS Windows  
Networking client for interacting with a Windows remote  
file server, here file server 78 on LAN 65. File sharing  
front end 520 is itself formed of state machine 522 and  
user interaction component 526 which communicate with  
10 each other through an application programming interface  
(API) as symbolized by line 524.

User interaction component 526 obtains, as  
symbolized by line 540, user interaction data, i.e.,  
15 URL/URI selection and form input, incoming from  
multiplexor 15 and contained in secure HTTP requests  
provided by user browser 15, representative of a user  
request to file server 78. Component 526 extracts the  
information from these web pages. This request can take  
20 the form of, e.g., the user clicking, through his(her)  
user browser, on a displayed icon in order to obtain a  
network environment ("network neighborhood") listing for  
the LAN or a directory or sub-directory listing for a  
particular computer then connected to the LAN. Once  
25 component 526 obtains sufficient user interaction data to  
issue the request to the file server, this component then  
translates this interaction data into a corresponding  
request to state machine 522. The state machine, in

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turn, interprets this request into a sequence of specific commands, by issuing one command at a time based, where appropriate, on a immediately prior response from the file server. In that regard, state machine 522 applies,  
5 as symbolized by line 515, a command to SAMBA component 510 which directly interacts, over the LAN and as symbolized by dashed line 505, with file server 78. File server 78 provides its response to that command back to SAMBA component 510 which, in turn, provides that  
10 response to state machine 522. Based on each response it receives, via SAMBA component 510 and via line 515, from file server 78, state machine 522 will react accordingly and could issue another command, via the SAMBA component, to the file server for additional data which the state  
15 machine then needs to fulfill the user request or, if all such data has then been received, construct a suitable response containing that data (if any) and provide it, via API 524, to user interaction component 526. Once the data has been provided to component 526, that component  
20 will retrieve, based on the nature of the user request and as symbolized by line 535, a corresponding stored HTML template page from stored pages 530 and populate that template page with the data returned in the list. Component 526 then returns, here symbolized by line 540,  
25 a resulting populated HTML page, via multiplexor 410, to web server 350 for transmission, via HTTP, to user browser 15 for rendering thereat.

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FIG. 16 depicts actual screen shot 1600 of a typical graphical display produced, at user browser 15, by component 420 for depicting and manipulated shared user files. This capability is invoked by the user  
5 having clicked on the "My Files" tab in display area 1610. Visual feedback of that selection is illustratively provided through a highlighted background for this tab.

10 As depicted in screen shot 1600, a network neighborhood, showing various computers then available on the LAN, appears in graphical form as a vertical list in left panel 1630 with each computer being represented by an icon and its machine name. Should a user click on any  
15 icon in the left panel, user interaction component 526 will generate, based on information it receives from state machine 522 and originating from file server 78, a hierarchical display under that icon, in effect expanding that hierarchy one level, to show a next lower level in  
20 the hierarchy, and so on. Hence, all the directories for the machine represented by the icon will be displayed directly under that icon and appropriately indented and graphically linked to show their hierarchical  
25 relationship. The contents at that lower level of the hierarchy or any user selected item at that level will be displayed in right panel 1640. The user can then click on any directory at that hierarchical level, on either the left or right panels, to gain a listing of the next

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lower hierarchical level, and so forth, with the further expanded hierarchy shown in left panel 1630 and the contents of any selected item at that lower level in that hierarchy shown in right panel 1640. At a lowest level

5 of the hierarchy, panel 1630 will depict the sub-directories at that level with panel 1640 depicting the files for a selected sub-directory thereat. By successively clicking on an icon in the hierarchy, the user can drill down the hierarchy to examine a particular  
10 sub-directory of interest on a desired networked machine available on LAN 65. The illustrative display in screen shot 1600 specifically depicts a high level of the hierarchy prior to the user selecting any of the network-connected computers for further examination.

15 Further, by clicking on an "Up", "New Folder", "Paste" or "Upload" button in display area 1620, the file sharing application module will display a next higher level of the hierarchy, create a new folder (or file), paste a folder into a desired location in the hierarchy or upload  
20 a selected folder residing on the remote client PC to a desired location at the file server, respectively. Note that popup menus are provided, at particular levels of the hierarchy, to allow for features such as the copying, deleting, etc. of files and directories at each such  
25 level.

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To gain improved understanding of the operation of file sharing application module 420, the reader should now simultaneously refer to FIGs. 6 and 7.

5           FIG. 6 depicts state diagram 600 for file sharing front-end state machine 522. FIG. 7 depicts illustrative inter-process communication 700 that involves file sharing application module 420, operative in conjunction with the file server 78, for obtaining and  
10           remotely displaying files for a given user.

          As shown, state machine 522 contains four distinct states: null state 610, command interpretation state 620, waiting for response state 630 and response  
15           construction state 640.

          Initially, state machine 522 resides in null state 610. One a user clicks on the "My File" icon in the Netilla virtual office graphical interface (e.g.,  
20           displays 1600, 1700 or 1800 shown in FIGs. 16, 17 or 18, respectively), this operation being symbolized by line 710, user browser 15 issues, symbolized by line 720, an appropriate HTTP request instruction ("HTTP\_GET\_REQ (/hosts)") to fetch a name of every host  
25           then on the LAN. File sharing front end 520, specifically user interaction component 526 (see FIG. 5), receives this command, and in response thereto, issues a command to the state machine, such as "GET\_SERVER\_LIST",

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to identify all the file servers on LAN 65. State machine 522 then transitions as symbolized by path 615 (in FIG. 6), to command interpretation state 620. While in this state, state machine 522 interprets the

5 "GET\_SERVER\_LIST" command to yield a sequence of commands to SAMBA component 510 to query component 510 for the desired information. In particular, for the "GET\_SERVER\_LIST" command, command interpretation state 620 will first issue, as symbolized by line 730, a

10 "NMBLOOKUP -M-" command to SAMBA component 510 to query file server 78 for a list of master browsers then operating on the LAN. A master browser identifies a computer that contains a list of names of all the computers then accessible on the LAN for a particular

15 domain. The SAMBA component will, in turn, send appropriate commands to file servers 78 to satisfy this query. Once this command is issued, state machine 522 will then transition, as symbolized by line 625, to state 630 wherein the state machine will simply wait, as

20 represented by line 633, for a response from the file servers as provided by SAMBA component 510. Eventually, the file server responds to the SAMBA query through which, as a result, SAMBA component 510 provides, as symbolized by line 740, a list of the master browsers for

25 each domain on the LAN to state machine 522 within file sharing front-end component 520. In response, state 630 will determine if the state machine has received all the responses from the file server needed to satisfy the user

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request or whether additional information is necessary.

If the latter occurs, then state 630 will transition, as symbolized by line 635, back to command interpretation state 620 for the latter state to issue the next SAMBA

5 command in sequence, and so forth. In the present example, once the list of master browsers is returned, command interpretation state 620 issues, as symbolized by line 750, an "SMBCLIENT -L hostname" command where

"hostname" is the name of the master browser for a particular domain on the LAN. In response to this latest command, again state machine 522 transitions, as symbolized by line 625, to state 630 at which the state machine remains (as symbolized by line 633) until it

10 receives an appropriate response from the file server via the SAMBA command. In response to this command, the file server returns a list of services, a list of shares and a list of computers associated with the corresponding domain, which the SAMBA component in turn, passes, as symbolized by line 760, back to file sharing front end 520 and specifically to state machine 522 therein.

20 At this point, all the needed information has been received for this particular user request. Hence, state machine 522 transitions, as symbolized by line 637, to response construction state 640. Through this state, state machine 522 constructs a linked list that contains  
25 all the information supplied by the file server in response to the "GET-SERVER-LIST" message (which was originally sent as a result of the receipt of the



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"HTTP\_GET\_REQ (/hosts) message" and provides that list  
back to user interaction component 526. Once this  
occurs, state machine 526 returns, as symbolized by  
line 645, back to null state 610. Once the user  
5 interaction component receives the linked list, it  
accesses an appropriate HTML template web page and  
populates that page with the information provided in the  
response. After the page is fully constructed, the user  
interaction component sends, as symbolized by line 770,  
10 that page back through multiplexor 410 to web server 350,  
via an "HTTP\_GET\_RESP" message, for transmission to user  
browser 15 to depict a graphical rendering of the hosts  
specified by the file server, e.g., a page of the form  
shown by screen shot 1600 for the typical display shown  
15 in FIG. 16. Response construction state 640, shown in  
FIG. 6, is also entered from state 630 if excess time,  
i.e., a timeout condition, has occurred once a command  
has been issued to the SAMBA component without any  
corresponding response therefrom (which could be as a  
20 result of a problem with the SAMBA component, with the  
LAN itself, or with server(s) on the LAN). As such,  
state 640 will specify this timeout condition to the user  
interaction component which, in turn, will construct and  
then transmit a web page to user browser 15 notifying the  
25 user of a timeout/error condition.

Not only can the user display files through  
interaction with user browser 15, but also, depending

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upon current permissions which this user then has, (s)he can move or copy selected files from one directory (sub-directory) to another, or delete such files. File sharing module 420, including state machine 522, operates in a very similar manner as that described above, with identical states though different commands, to execute file copy, move and delete operations through file server 78 in response to corresponding remote user interactions through user browser 15.

FIG. 8 depicts a block diagram of e-mail application module 430 that forms a part of virtual office software 400 shown in FIG. 4. As noted above, module 430 interacts with a client e-mail IMAP handler to access and retrieve user e-mail stored on an e-mail server as well as to manipulate stored e-mail residing in his(her) e-mail folders (Inbox, Outbox, Sent Mail and the like) residing on that server.

Module 430 contains IMAP (Internet Message Access Protocol) client component 810, e-mail front end component 820 and HTML pages 830. As can be appreciated, module 430 has a very similar architecture to file sharing application module 420 shown in FIG. 5, as well as to thin-client application module 440 shown in FIG. 11 (and discussed in detail below).

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IMAP client component 810 is a conventional e-mail client component that provides rich interaction with a mail server, such as Microsoft Exchange server, that supports the IMAP4 protocol. For example, the IMAP client downloads and displays stored e-mail messages, residing on the mail server, from an Inbox associated with a user. The IMAP client then permits the user to move and copy mail messages from one folder at the server associated with that user (e.g., Inbox) to another such folder (e.g., Sent), as well as delete any such messages from any such folder. E-mail front end 820 is itself formed of state machine 822 and user interaction component 826 which communicate with each other through an application programming interface (API) as symbolized by line 824.

User interaction component 826 (in a similar manner as does user interaction component 526 described above) obtains, as symbolized by line 840, user interaction data, i.e., form input data and URI/URL selections, incoming from multiplexor 15 and contained in HTTP requests provided by user browser 15, representative of a user request to e-mail server 76. Component 826 extracts the information from these requests. This request can take the form of, e.g., the user clicking, through user browser 15, on the "My E-mail" tab to access and list the user's e-mail then residing in his(her) Inbox on the e-mail server. Such an interaction results

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in the user browser issuing an "HTTP\_GET\_REQ (/Inbox)" message (request) to obtain an HTML page in response (via an HTTP Response) that contains the desired list.

Further, once this page and its list are returned and graphically rendered by the user browser, subsequent user interaction can take the form of the user clicking on an icon associated with a different folder of e-mail messages to obtain a list of the messages, in abbreviated form, in that folder; as well as the user clicking on any such entry in any such list then being displayed to expand that rendered version of the message. Similarly, the user, through appropriate mouse manipulation, can drag and drop, hence rearranging, e-mail messages from one of his(her) folders to another.

Once component 826 obtains sufficient user interaction data from the user -- which in the simple case of the user clicking on the "My E-mail" tab is the HTTP request message, via web server 350 (see FIG. 3A) and multiplexor 410, to issue a request to the e-mail server, this component then translates this interaction data into a corresponding request to state machine 822, shown in FIG. 8. The state machine, in turn, interprets this request into a sequence of specific commands, by issuing one command at a time based, where appropriate, on a immediately prior response from the e-mail server. In that regard, state machine 822 applies, as symbolized by line 815, a command to IMAP client component 810 which

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directly interacts, as symbolized by dashed line 805 and over LAN 65, with e-mail server 76. E-mail server 76 provides its response to that command back to IMAP client component 810 which, in turn, provides, via line 815, that response to state machine 822. Based on each response it receives, via IMAP client component 810, from e-mail server 76, state machine 822 will react accordingly and issue another command, via the IMAP client component, to the e-mail server for additional data which the state machine then needs to fulfill the user request or, if all such data has then been received, construct a suitable response containing that data and provide it, via API 824, in the form of a linked list to user interaction component 826. Once the linked list has been provided to component 826, that component will retrieve, based on the nature of the user request and as symbolized by line 835, a corresponding stored HTML template page from stored pages 830 and populate that template page with the data returned in the list. Component 826 then returns, here symbolized by line 840, a resulting populated HTML page, via multiplexor 410, to web server 350 for transmission, via HTTP, to user browser 15 for rendering thereat.

FIG. 17 depicts screen shot 1700 of a typical graphical display produced, at user browser 15, by component 420 for depicting e-mail messages. This capability is invoked by the user having clicked on the

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"My E-mail" tab in display area 1710. Visual feedback of that selection is again illustratively provided through a highlighted background for this tab.

5                   As depicted in display 1700, a vertical list of the e-mail folders available for that user is graphically provided in left display panel 1730. These folders include "Inbox", "Drafts", "Sent Items" as well as other folders, such as "Spam", including those which the user  
10                   has specifically defined. When this capability is first invoked, a listing of the user's e-mail in his(her) Inbox folder is displayed in abbreviated form in mail list (upper right) display area 1740 as entries in a vertical table with contents of a most recent entry in that folder  
15                   being displayed in mail content (lower right) display area 1750. Here, that table contains only one illustrative entry with its specific contents being displayed. Should the mail list contain multiple entries, the user can click on any such entry. In  
20                   response, user interaction component 826 will display the contents of the message, associated with that entry, in display area 1750. The specific folder then being displayed is graphically indicated through a change (here being a small overlaid envelope symbol) in its displayed  
25                   icon (as shown for the Inbox icon). Similarly, if the user clicks on an icon for a different folder, then display area 1740 will list the contents of that folder from which the user can select, again by clicking, a

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desired entry to reveal its contents in display area 1750. In addition, through tool 1760, specifically selection of either a "Move" or "Copy" link within links 1763 and selection of a desired folder through pull-down menu 1767, the user can move or copy the presently displayed e-mail message to the selected folder. Contacts display area 1770 provides various folders which contain contact information, e.g., names, addresses -- both postal and e-mail, telephone and facsimile numbers, and other information stored and organized by that user in various folders. Further, when the user clicks on a "New Mail", "Reply", "Reply All" or "Forward" button in display area 1720, the e-mail application module will correspondingly invoke associated functionality to compose a new e-mail message; compose a reply message to the sender of a message then being displayed in area 1750 or to the sender and all recipients of that message, or forward the message then being displayed in area 1750 to a desired recipient, such as those in any of the contacts folders. By clicking on a "Print" or "Delete" button in area 1720, the e-mail application module will invoke associated functionality to print the e-mail message then selected in area 1740 or displayed in area 1750, or to delete that message, respectively. Lastly, when the user clicks on the "Send/Rec", "Addresses", "Purge" or Find" buttons, the e-mail application module will correspondingly invoke functionality to toggle its mode from receiving to

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5        sending e-mail, list addresses through a conventional  
address book capability, purge a mail folder then being  
displayed of its entries, and finally undertake a search  
through an e-mail folder then being displayed for a  
desired message.

      To gain improved understanding of the operation  
of e-mail application module 430, the reader should now  
simultaneously refer to FIGs. 9 and 10.

10

      FIG. 9 depicts state diagram 900 for e-mail  
front-end state machine 822. FIG. 10 depicts  
illustrative inter-process communication 1000 that  
involves e-mail module 430, operative in conjunction with  
15        the e-mail server 76, for retrieving user e-mail messages  
residing on that server.

      As shown, state machine 822 contains four  
distinct states (similar to those in state diagram 600  
20        shown in FIG. 6 for state machine 522 in file sharing  
application module 420): null state 910, command  
interpretation state 920, waiting for response state 930  
and response construction state 940.

25        Initially, state machine 822 resides in null  
state 910. Once a user clicks on the "My E-Mail" icon in  
the Netilla virtual office graphical interface (e.g.,  
displays 1600, 1700 or 1800 shown in FIGs. 16, 17 and 18,



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respectively), this operation being symbolized by  
line 1010, user browser 15 issues, as symbolized by  
line 1015, an appropriate HTTP request instruction  
("HTTP\_GET\_REQ (/Inbox)") to fetch the contents of the  
5 user's Inbox. The e-mail application module, now acting  
through the IMAP client, interacts with the e-mail  
server, via the IMAP protocol, to retrieve a message list  
for the user's Inbox.

10 In doing so, e-mail front end 820, specifically  
user interaction component 826 (see FIG. 8) receives this  
HTTP command, and in response thereto, issues a command,  
"GET\_INBOX\_LIST", to state machine 822. State  
machine 822 then transitions as symbolized by path 915,  
15 to command interpretation state 920. While in this  
latter state, state machine 822 interprets the  
"GET\_INBOX\_LIST" command to yield a sequence of commands  
to IMAP client component 810 to query e-mail server 76  
for the desired inbox mail list.

20 For this command, command interpretation  
state 920 will first issue, as symbolized by line 1020, a  
"A101 SELECT INBOX" command to the e-mail server to  
select the proper inbox on the e-mail server. Term  
25 "A101" (as well as similar term "A102", and so forth) is  
a transaction tag assigned to this particular interaction  
between the state machine and the e-mail server such that  
server responses can be paired, by the state machine,

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with appropriate IMAP client requests. Identical circled numerals are shown in FIGs. 9 and 10 in order for the reader to visually correlate specific inter-component messages shown in communications 1000 with their

5 corresponding events (including state transitions) in state diagram 900. Once the "SELECT INBOX" command is issued, state machine 822 will then transition, as symbolized by line 925, to state 930 wherein the state machine will simply wait, as represented by line 934, for

10 a response from the e-mail server as provided by IMAP client component 810. Eventually, the e-mail server responds to the "SELECT INBOX" command through which, as a result, IMAP client 810 provides, as symbolized by lines 934 and 1025, an indication of the number of

15 messages in the user's Inbox. In the example shown in FIGs. 9 and 10, the response is "\*3 EXISTS" which signifies that the Inbox contains three messages. This is followed, as symbolized by line 1030, by a "A101 OK [READ-WRITE] SELECT completed" response from the IMAP

20 Server indicating that the A101 transaction has been completed, and that the Inbox can be read or written during this session. In response, state 930 will determine if the state machine has received all the responses from the e-mail server needed to satisfy the

25 user request or whether additional information is necessary. For the example shown, at this point in the processing, state 930 will determine that messages need to be fetched from the e-mail server. Accordingly, once

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the "A101 OK [READ-WRITE] SELECT completed" message is received, state 930 will transition, as symbolized by line 932, back to command interpretation state 920 for the latter state to issue subsequent IMAP commands as necessary. Illustratively, here, command interpretation state 920 will issue, as symbolized by lines 936 and 1035, a "FETCH 1:3" command to the e-mail server to fetch the three queued messages in the Inbox. Here, tag "A102" is attached to this message to uniquely define this interaction. Included in the "FETCH" command are parameters indicating that "date" and "date from field" data from the header for each message should be fetched as well. At this point, the e-mail server issues individual fetch responses, here shown as "\*1 FETCH", "\*2 FETCH" and "\*3 FETCH" and as represented by lines 1040, 1045 and 1050 in communication 1000, back to the e-mail front end. During this time, state machine 822 will remain in state command interpretation state 930 as indicated by line 938. Each response contains the fetched information for a corresponding e-mail message in the user's Inbox. Once all three messages have been successfully fetched, the e-mail server, as indicated by line 1055, issues an "A102 OK FETCH" message which indicates the completion of this transaction. In response to this completion message, state 930 will determine that all the necessary responses have been received from the e-mail server. Hence, state machine 900 transitions, as symbolized by line 937, to

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response construction state 940. Through this state, state machine 822 constructs a linked list, here list 950, that contains all the user messages supplied by the e-mail server in response to the "HTTP\_GET\_REQ (/Inbox)" message and provides that list back to user interaction component 826. Once this occurs, state machine 826 returns, as symbolized by line 945, back to null state 910. Once the user interaction component receives the linked list, it accesses an appropriate HTML template web page and populates that template page with the information provided in the response to yield, e.g., a page of the form shown by display page 1700 shown in FIG. 17 (with an Inbox icon in a left panel and titles to individual e-mail message in a right panel). After this page is fully constructed, the user interaction component sends, as symbolized by line 1060 in FIG. 10, that page back through multiplexor 410 to web server 350, via an "HTTP\_GET\_RESP" message, for transmission to user browser 15 to depict the web page providing the e-mail messages downloaded from the e-mail server. Response construction state 940 is also entered from state 930 if excess time, i.e., a timeout condition, has occurred once an IMAP command has been issued to the e-mail server without any corresponding response therefrom. As such, state 940 will specify this timeout condition to the user interaction component which, in turn, will construct and then transmit a web page to user browser 15 notifying the user of an timeout/error condition.

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Not only can the user download his e-mail messages through interaction with user browser 15, but also, as discussed above, the user can move or copy selected e-mail messages from one e-mail folder to another, or delete any such messages. E-mail application module 430, including state machine 822, operates in a very similar manner as that described above, with identical states though different commands, to execute e-mail copy, move and delete operations through e-mail server 76 in response to remote user interactions through user browser 15.

Furthermore, the user can also send an outgoing e-mail message through appropriate interaction with user browser 15 and particularly using e-mail application module 430. Specifically, whenever the user clicks on "New Mail" button in area 1720 on e-mail display screen 1700 shown in FIG. 17, user interaction component 826 shown in FIG. 8 will interpret that response, as originated from user browser 15, and access a correct HTML e-mail form from stored web pages 830 and return that form, as symbolized by line 840, back to the user browser to be rendered to the user. Once the user appropriately completes the form, (s)he will click on the "Send/Rec" button in area 1720 to send the message. This interaction, originating from user browser 15 and when received by user interaction component 826 shown in FIG. 8, will cause that component to receive the form

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containing the e-mail from the user browser. Once the form is so received, user interaction component 826 will extract the content, including the sender and recipient addresses, of the particular e-mail message from the received form and then issue a command to state machine 822, via API 824, to send that content out to the e-mail server for transmission. This command will be a "SEND\_MAIL\_REQ" which will contain as a parameter the e-mail to be sent. To accomplish this, state machine 822 interacts with two components to actually send this outgoing e-mail message: SMTP (simplified mail transport protocol -- conventional and not shown) and IMAP client 810. The SMTP interaction provides the e-mail message and actually instructs the e-mail server to transmit the e-mail onward to its destination. Once this interaction concludes, state machine 822 interacts with the IMAP client in order to update the "Sent Mail" folder, maintained on the e-mail server, for that particular user to include this message in its listing of sent e-mail messages. The interaction involving state machine 822, via the IMAP client, and the e-mail server is very similar to that used to read the Inbox, though different commands are used in order to write a message into the user's "Sent Mail" folder rather than read the user's "Inbox" folder. Once state machine 822 has successfully sent the e-mail to the server for transmission, the state machine then sends a positive response, i.e., an appropriate "SEND\_MAIL\_RESPONSE", to

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user interaction component 826. If this user interaction component maintains a local HTML page containing titles of all e-mails in the user's "Sent-Mail" folder, component 826 updates that HTML page to include the message that has just been sent and then supplies that page, as here symbolized by line 840, back to user browser 15 for rendering to the user. Alternatively, the user interface component can also access, as symbolized here by line 835, a predefined HTML page, from stored pages 830, that merely contains a confirmation that the e-mail message was successfully sent and provide that particular web page, here too symbolized by line 840, back to web server 350 for transmission, via HTTP, to user browser 15 for rendering to the user as appropriate visual confirmation that his(her) message was transmitted. If an external e-mail server is not used, then the IMAP client interacts with Sendmail module 360 (shown in FIG. 3A) instead.

Though we have described the interaction for both the file sharing and e-mail application modules as illustratively user-initiated, i.e., starting with a user request entered at user browser 15, the interaction can be server-initiated as well, with either file server 78 or e-mail server 76, via SAMBA component 510 or IMAP client 810, respectively. In this case, as will be described below in connection with RDP client 1100 (in conjunction with FIG. 12B), a server-initiated request

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will be directed to the corresponding state machine, be processed by that state machine, and if appropriate, forward resulting data onward to the corresponding user interaction component to be incorporated into an appropriate web page and then transmitted to user browser 15 for rendering to the remote user.

Alternatively, in some cases, once the state machine has processed the request, the state machine may, depending on the nature of the data supplied by the server, generate further commands to the server. Though the specific commands and transition events will likely vary, the state processing will be quite similar to that shown and described herein.

FIG. 11 depicts a block diagram of thin-client application module 440 that forms a part of software 400 shown in FIG. 4. As noted above, module 440 interacts through the remote desktop protocol (RDP) with a client application program then being hosted on server 70.

Module 440 receives user mouse clicks and keystrokes from the user browser, in AIP form or some other similar form, and passes that information, via RDP, to the client application program to control its execution. In return, this module obtains graphical output displays, as screen shots, generated by the client application program and in RDP form, and converts those screen shots into AIP form and then transmits AIP messages, containing the screen shots, back to the user, specifically the user browser



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for rendering thereat. Note that module 440 can also receive control information from the user browser via AIP or some similar protocol. This information will typically not require any interaction with the application server via RDP. For example, thin-client Java applet 1180 running within the browser could request from the SEP a list of the applications that the user has access to at startup time. Based on the response, applet 1180 would display icons representing these applications. This whole interaction would occur via the AIP (or some similar protocol). Alternatively, based on implementational considerations, such control interactions could also use a completely separate protocol from the data interactions such as keystrokes, mouse clicks, and screen updates.

Module 440 contains RDP component 1110, thin-client front end component 1120, stored HTML pages 1130 and user database 1190.

Thin-client front end 1120 is itself formed of state machine 1122 and user interaction component 1126 which communicate with each other through an application programming interface (API) as symbolized by line 1124. State machine 1122, in a similar fashion to state machines 522 and 822 (in file sharing front end 520 and e-mail front end 820 shown in FIGs. 5 and 8, respectively), interacts with an RDP client

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component 1110 which, in turn, interacts with client applications server 72. User interaction component 1126, in a similar manner to user interaction components 526 and 826 (in file sharing front end 520 and e-mail front end 820 shown in FIGs. 5 and 8, respectively), interacts with user browser 15 and passes and receives application information to and from the state machine. Protocol engine 1160, described below, receives user interaction data, i.e., user mouse clicks and keystrokes in the form of AIP messages, from user browser 15 that are related to a client application program then executing on server 72 and sends screen updates to the user browser for display thereat.

RDP component 1110 is conventional and implements a client side of the RDP. Specifically, it interacts directly with client application server 72 using RDP by translating commands from a format used by state machine 1122 into the RDP for application to server 72 and translating responses received from this server into an appropriate format for use by state machine 1122.

User interaction component 1126 contains generic web page module 1150 and protocol engine 1160. Generic web page module 1150 responds to a request from the user, and specifically user browser 15, that does not directly involve the execution of a thin-client

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application program. For example, when the user first clicks on the "My Apps" tab, an HTML page that contains a Java applet that controls input/output to executing thin-client application programs, using the AIP protocol, is downloaded to the browser and then instantiated under the browser to become Java applet 1180.

As shown in FIG. 11, user interaction data in the form of user mouse clicks and keystrokes is provided by user browser 15 and specifically through execution of conventional internal Java applet 1180 that encodes this data into the AIP protocol. Additionally, control information is passed between the Java applet and the SEP to enable the applet to, for example, correctly display the icons for the client application programs that a particular user can access. For the discussion that follows, this control data is also sent via the AIP protocol. In general, this data could be sent by the same protocol as is used for transfer of the user interaction data in the form of mouse clicks and keystrokes, or by some alternate protocol.

In any event, user interaction component 1120 obtains, as symbolized by line 1165, AIP message data incoming from multiplexor 410. This message can take the form of a message indicating that a user has clicked on one of his(her) displayed client application program icons to invoke that particular application. Protocol

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engine 1160 within component 1126 extracts the interaction data from the AIP message and applies it to state machine 1122. The state machine, in turn, provides, as symbolized by line 1115, this command to RDP component 1110 which converts it into a corresponding RDP message. Component 1110 then sends that RDP message, over the LAN and as symbolized by dashed line 1105, to client application server 72. Server 72 then extracts the interaction data from the RDP message and applies it to the corresponding client application program then executing, or in the case of a user initially clicking on a client application program icon displayed by the user browser, launches that application on the server. The resulting graphical display produced by the application is then returned by the server, within an RDP message and also as symbolized by dashed line 1105, back to RDP component 1110. This component, in turn, provides the display data to state machine 1122. The state machine will react accordingly and provide that data, via API 1124, to user interaction component 1126. This component, through protocol engine 1160, converts that display data (screen shot) into an AIP message and then transmits that message, via multiplexor 410 and web server 350, to user browser 15 to update the application display then being rendered thereat. Within the browser, Java applet 1180 converts the AIP message into an appropriate display to the user within the window

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assigned for this particular instance of the remotely executing client application program.

Protocol engine 1160 does not always need to  
5 interact with state machine 1122. For example, when Java applet 1180 sends a request to the protocol engine for a list of client application programs to which the user can access (via the control portion of the AIP protocol or via a separate control protocol), the protocol engine can  
10 refer, as symbolized by line 1195, to local user database 1190 for that application list. Once the list is returned to engine 1160, that engine, in turn, will instruct the Java applet as to which specific applications to graphically display to the user.  
15 Alternatively, rather than accessing local user database 1190, protocol engine 1160 could access a non-local database through a conventional protocol, such as LDAP.

20 When the user clicks on the "My Apps" tab as displayed by user browser 15 in order to invoke thin-client application program hosting, a display similar to that shown in screen shot 1800 depicted in FIG. 18 is rendered as a result. Visual feedback of that  
25 selection is again illustratively provided through a highlighted background for this tab in display region 1810. Those specific client application programs to which the user can access are displayed through

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5       separate graphical icons 1830 situated in display  
area 1820. The user can then click on any of these icons  
to remotely launch the associated client application  
program in a separate browser window through which the  
user can fully interact with that application.

10       To gain improved understanding of the operation  
of thin-client application module 440, the reader should  
now simultaneously refer to FIGs. 12A, 12B and 13.

15       FIGs. 12A and 12B depict state diagrams 1200  
and 1250 for thin-client front-end state machine 1122 for  
user- and server-initiated interactions, respectively.  
The user-initiated interaction involves, e.g., startup of  
a client application program session, in response to a  
user command provided from user interaction  
component 1126; the server-initiated interaction  
involves, e.g., an update, provided by client application  
server 72 and via RDP component 1110, to an application  
20       display then being rendered by user browser 15. FIG. 13  
depicts illustrative inter-process communication 1300  
that involves thin-client module 440, operative in  
conjunction with the client application server 72, for  
executing and interacting with hosted client application  
25       programs.

As shown, state machine 1122 contains four  
distinct states (similar to those in state diagrams 600

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and 900 shown in FIGs. 6 and 9 for state machine 522 and 822 in file sharing application module 420 and e-mail application module 430, respectively): null state 1210, command interpretation state 1220, waiting for response  
5 state 1230 and response construction state 1240.

Initially, state machine 1122 resides in null state 1210. One a user clicks on the "My Apps" icon in the Netilla virtual office graphical interface (e.g.,  
10 displays 1600, 1700 or 1800 shown in FIGs. 16, 17 and 18, respectively), this operation being symbolized by line 1305, user browser 15 issues, as symbolized by line 1310, an appropriate HTTP request instruction ("HTTP\_GET\_REQ (/Apps)") to fetch a list of the client  
15 application programs which that user can access. User interaction component 1126 receives this command, and in response thereto, issues, as symbolized by line 1315, an HTTP\_GET\_RESP message containing an HTML page with an embedded Java applet. Once downloaded into user  
20 browser 15, this Java applet is instantiated by the browser as Java applet 1180 (see FIG. 11) and then issues, as symbolized by line 1320, a query, "User\_Desktop\_Query", to thin-client front end 1120 for a list of the user's accessible hosted client application  
25 programs. As a result of this query, component 1126 in thin-client front end 1120 returns, as symbolized by line 1325 (see FIG. 13), a response, "User\_Desktop\_Response", based on stored user information

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contained within user database 1190, containing a list of those application programs. Thereafter, Java applet 1180 executing in the browser displays an icon on user browser 15 for each of these application programs. At  
5 this point, the user, being provided with a graphical display such as display 1800 shown in FIG. 18, can click on any of these icons to invoke the corresponding client application program.

10 If the user then clicks on any such icon, e.g., that associated with the Microsoft Word program, this interaction being symbolized by line 1330, Java applet 1180 spawns a new browser window (which the applet controls) for use as a user display area for that  
15 particular remotely hosted application program. In addition, then user browser 15 provides, as symbolized by line 1335, a "Session\_Start" command to thin-client front end 1120. This command includes the name of an application server (server 72 as shown in FIG. 1),  
20 appropriate flags, a domain within which the application server runs, password of the user, the name of the application program (here "Word"), a name of a working directory and other related parameters needed to properly and remotely execute the application program (including  
25 fully defining its user environment).

In response to the "Session\_Start" command, state machine 1200 transitions, as symbolized by



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line 1215 in FIG. 12A, from null state 1210 to command interpretation state 1220 where it processes this command. Similar to FIGS. 9 and 10, identical circled letters, rather than numerals, are shown in FIGs. 12A, 12B and 13 in order for the reader to visually correlate specific inter-component messages shown in communications 1300 with their corresponding events (including state transitions) in state diagrams 1200 and 1250. Specifically, while in state 1220, the state machine issues, as symbolized by line 1340, an "RDP\_CONNECT\_REQ" request message to client RDP component 1110 to request a session with a particular client application server. This request contains, e.g., the server, directory, application program (e.g., the Microsoft Word program) and other information provided, in the Session\_Start command, to the thin-client front end. Once this message is issued, state machine 1200 transitions, as indicated by line 1225, to waiting for response state 1230, waiting for a response from the client application server, e.g., server 72 shown in FIG. 1.

Once the server has established the requested application session, the server issues an appropriate message to client RDP component 1110 as shown in FIGs. 12A and 13, which, in turn, provides, as symbolized by line 1340, an RDP connect response message, "RDP\_CONNECT\_RESP", to the thin-client front end. In

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response to this RDP message, state machine 1122 remains, as symbolized by line 1233, in this state to determine if this is the only response that the state machine has been expecting from the client application server or not. If  
5 it is, as is the case here for session startup, then state machine 1122 transitions, as indicated by line 1237, from state 1230 to response construction state 1240. Once in the latter state, state machine 1122 constructs an appropriate session start response message.  
10 i.e., "SESSION\_START\_RESP", to user interaction component 1126 after which the state machine transitions, as symbolized by line 1245, back to null state 1210. As a result of this response message, the user interaction component sends a "Session\_Start\_Resp" message, as  
15 symbolized by line 1350, to user browser 15 and specifically to Java applet 1180 executing thereunder to indicate that the desired application session has been established. In essentially the same manner as just described, subsequent user-initiated interactions, i.e.,  
20 mouse clicks and keystrokes, with the executing application program will be provided by the user browser and processed through the thin-client front end and translated from AIP into appropriate RDP messages which, in turn, are provided to client application server 72 to  
25 control execution of that application program.

Returning to the example shown in FIG. 13 for startup of an remotely hosted thin-client application

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program session, once the application session has been established and the application invoked at server 72, the server will provide RDP client component 1110 with an initial graphical display screen. In response, RDP

5 component 1110 will issue, as symbolized by line 1355, an "RDP\_PROCESS\_BITMAP\_UPDATES (stream)" message containing screen bitmap display data for display. In response to this RDP message, state machine 1122 will transition, as symbolized by line 1263 in FIG. 12B, from null state 1210

10 to command interpretation state 1220. In this latter state, the state machine will simply pass this bitmap data onward to user interaction component 1126 within thin-client front end 1120 such that this data can be forwarded to the user browser for rendering thereat. As

15 such, state machine 1122 will issue, as symbolized by line 1360, an image update command, "IMAGE UPDATE", to the user interaction component, and, as symbolized by line 1267, transition back to null state 1210. In response to this state machine command, the user

20 interaction component performs certain initial processing of this bitmap data. In particular, given limited display capabilities of a Java virtual machine executing in user browser 15, this processing includes operations not supported by that virtual machine, such as, e.g.,

25 plane masking, logical operations and others. In addition, the user interaction component, through use of protocol engine 1160, will also determine if Java applet 1180 has cached any portion of the display that

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can be reused in the updated display, e.g., a glyph representing a character, hence eliminating a need to resend that portion so as to conserve transmission bandwidth and expedite update time by user browser 15.

5 At the conclusion of this processing, user interaction component 1126 within thin-client front end 1120 will send, as symbolized by line 1360, a "Display\_Screen (Image)" message containing the update display data to user browser 15 for rendering thereat in the  
10 corresponding window spawned to support this particular client application program. In the same manner as described, subsequent server-initiated interactions, i.e., bitmap display screens, for this program will be provided by client application server 72 and processed  
15 through the thin-client front end and translated from RDP into appropriate AIP messages which, in turn, are provided to user browser 15 to appropriately update the display in the corresponding application window.

20 We will now proceed to describe how the Remote Monitoring and Management (RMM) aspect of our present invention is implemented.

FIG. 19 depicts, at a very high level,  
25 software 1900, organized by protocol layers, that implements the RMM capability, through web site 20, for LAN 65 connected to SEP 200. During installation of the SEP at a customer site, a web connection is established

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between the SEP and CCC 20 through which configuration information in the form of a configuration profile including, among other parameters, predefined configuration data and IP addresses for the LAN to which  
5 that SEP is to be connected, is downloaded from web site 20 and then stored for subsequent use within the SEP. In addition, site 20, at its own request, can request download of a current profile stored within the SEP to the web site. Furthermore, during SEP operation,  
10 the SEP can establish a web connection with site 20 through which the SEP can report its operational data and/or any alarm condition as well as, in response to a user request, obtain a latest version of its configuration profile from the web site. Furthermore,  
15 web site 20 can monitor the version number of the software modules executing in the SEP and, if a newer version (update or upgrade) of any such module is then available, download and automatically install that version on the SEP.

20 As shown, software 1900 is composed of management software 2000 that executes, as a daemon process, in SEP 200 and service monitoring software 1950 that executes in administrative web site (CCC) 20.

25 Software 2000 and 1950 utilize the same protocol hierarchy (stack): at uppermost levels of the hierarchy, service monitoring agent 2010 in software 2000 and service monitoring manager 2230 in software 1950,

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followed, in order, by WDDX layers 1905 and 1955, XML layers 1910 and 1960, HTTP layers 1915 and 1965, SSL layers 1920 and 1970, and at the lowest level of the hierarchy: TCP/IP layers 1925 and 1975, respectively.

5

Service monitoring agent 2010 can be programmed to continually monitor the health and operational status of the SEP and its network connections (e.g., WAN connection), the virtual office applications and their corresponding servers (e.g., servers 72, 74, 76 and 78 as shown in FIG. 1), and, in doing so, receives alarm, status and configuration data, as symbolized by line 1903, from various SEP hardware and software components. This data, in the case of routine reports, is obtained by polling.

10

15

Communication from agent 2010 destined to CCC 20 is first routed to WDDX module 1905. This module is an open source component presently available from Macromedia, Inc. of San Francisco, California. In essence, WDDX module 1905 converts data objects provided by agent 2010 into WDDX hash structures. These structures are provided to XML layer 1910 which, in turn, encodes specific data fields therein (given the particular fields that are to then be encoded) into appropriate XML (extensible markup language). The resulting XML is then applied to HTTP layer 1915 for conversion into corresponding HTTP messages for transport

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over the web to a peer HTTP process (here process 1965).  
Thereafter, to secure the transmission, the resulting  
HTTP messages are then encrypted by SSL layer 1920  
(implemented through Open SSL module 340 and using  
5 certificate 284, shown in FIG. 3A) with the results being  
applied to TCP/IP layer 1925 (implemented by TCP/IP  
processing module 370 shown in FIG. 3A) for  
encapsulation, packetizing and packet transport, as  
symbolized by line 1930, over WAN 30 to web site  
10 (CCC) 20.

Incoming messages to CCC 20 from WAN 30 are  
handled by service monitoring software 1950, and  
processed through essentially the same protocol  
15 hierarchy, though in a reverse direction. This  
processing commences with TCP/IP layer 1975 for packet  
disassembly and related packet processing of these  
incoming messages, as symbolized by line 1985, with  
resulting encapsulated encrypted HTTP messages then being  
20 applied to and decrypted by SSL layer 1970. Resulting  
decrypted HTTP messages are applied to HTTP layer 1965  
which extracts the XML content therefrom and then applies  
these messages to XML layer 1960 which converts the data  
within the XML into a corresponding WDDX hash  
25 structure(s). Thereafter, WDDX layer 1955 extracts  
various data fields from the WDDX hash structure and, in  
turn, applies these fields to service monitoring  
manager 2230. Manager 2230 then accesses and updates

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appropriate records within database 1980, such as to log alarm information provided by the SEP or modify stored profile data based on a profile downloaded by the SEP through monitoring agent 2010.

5

Communication originating from CCC 20 and destined to SEP 200 follows a reverse path commencing at manager 2230 accessing desired data (e.g., a stored configuration profile) within database 1980, then  
10 sequentially downward through the remainder of the stack shown in software 1950 to yield encrypted packetized HTTP messages that are sent through WAN 30. When received by the SEP, these messages are then processed upward through the stack in software 2000 with the resulting data being  
15 appropriately provided to and handled by agent 2010, such as by updating a stored database in the SEP to reflect the data provided by the CCC.

FIG. 20 depicts a very high-level block diagram  
20 of software 2000.

As shown, software 2000 contains component 2010 itself formed of remote monitoring/management (RMM) process 2020, connection service monitoring (CSM)  
25 process 2030 and remote monitoring transport (RMT) process 2040; and routines 2050.



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RMM process 2020, when it instantiates at SEP start-up, spawns, to the extent relevant, two child processes: CSM process 2030 and RMT process 2040. All of these processes are daemon processes. RMM 2020 accepts  
5 incoming SEP-generated alarm information, as symbolized by line 2015. This process: (a) generates a request ultimately to manager 2230 in web site 20 to download a customized configuration profile in the event that only a default profile is then available on the SEP, such as  
10 during SEP installation (i.e., initial start-up); (b) coordinates delivery of alarms to web site 20, specifically manager 2230 therein; and (c) sends poll messages, over dial-up link 59 (see FIG. 1) to web site 20, during a failure of the broadband connection to  
15 the WAN. These poll messages permit the CCC to obtain a current IP address of that SEP such that the CCC can update database 1980 to reflect that address and hence communicate with that SEP. In particular, since the broadband WAN link to the SEP has a static IP address,  
20 should this link fail, the SEP will establish a dial-up connection to the Internet, via dial-up link 59. However, in establishing that link, the ISP into which the SEP dials, will assign dynamically assign an IP address to the SEP -- an IP address which will not match  
25 that previously stored in CCC database 1980. Hence, the need then arises for the SEP to provide its new IP address to the CCC. Polling is required inasmuch as the SEP will terminate its current dial-up session with the

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ISP and establish a new session from time to time; hence, receiving a new IP address each time which must be communicated to the CCC. This particular polling stops once the broadband WAN link is fully restored.

5

In addition, to the extent that any entity in the SEP, or residing on or connected to the LAN is incapable of generating an alarm, the RMM process can be configured to poll that entity for its status, report that status back to the CCC and report an alarm, when necessary.

10

Alarm coordination entails determining, in the event of multiple web servers being associated with web site 20 (or multiple such sites) which specific web site is to receive current alarms from SEP 200, as well as prioritizing and queuing alarms for delivery. Furthermore, RMM process 2020 utilizes a shared memory queue into which software executing on the SEP can insert an appropriately formatted alarm message, thus, accommodating alarms generated by processes other than CSM process 2030 (e.g., alarms 2015). In that regard, the configuration profile specifies a list of alternate CCC web servers which RMM process 2020 will utilize if it experiences a problem in delivering alarms to web site (CCC) 20. In that regard, should such a delivery problem be detected, the RMM process will use a round-robin algorithm in selecting an alternate delivery site from

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those CCC servers specified in the list. For local redundancy, particularly in the event of a failed delivery to the CCC, RMM process 2020 also records all alarms it receives in a local database. RMM process 2020 attempts delivery of alarm information a prescribed number of times as specified by the configuration profile, with a random delay between successive attempts. RMM process 2020 also monitors the health of CSM and RMT processes 2030 and 2040, respectively, (with each of these processes also monitoring RMM process 2020), and, if it detects any anomalous behavior, terminates all three processes (with each of the other three processes terminating the others, if necessary). A "cron" daemon checks every quarter-hour to determine whether RMM is running or not and re-starts RMM if it is not.

CSM process 2030, once started, reads a user specified configuration file (stored profile previously downloaded from web site 20) that indicates which specific connections and servers and/or groups thereof (and/or other entities) are to be monitored. At a user specified frequency, the CSM process conducts various conventional tests to determine the health of the items then being monitored. If any such test indicates a fault, then CSM 2030 generates an appropriate alarm to RMM 2020. Tests are server and function specific, in the sense that, e.g., a test for E-mail server 76 (see FIG. 1) is different from that for thin-client server 72

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and for any of the thin-client virtual office applications then executing thereon. Tests also fall into two categories: those which generate a pair of alarms, namely one where a service failure occurs and a  
5 corresponding one when service is appropriately restored; and (b) those that generate an alarm every time a failure is detected, but do not generate an alarm when that failure is resolved.

10 RMT process 2040 provides reliable delivery of alarm information between SEP 200 and web site 20, as well as managing an interface between RMM process 2020 and routines 2050. In operation, RMT process 2040 spawns a Perl interpreter and pushes/pops data off a resulting  
15 stack.

Specifically and as described in detail below in conjunction with FIG. 21, RMT process 2040 utilizes, as symbolized by line 2055, a set of Perl Remote  
20 Management Scripts (RMS) 2050 to transport messages between SEP 200 and from web site 20. These scripts utilize a layer of routines (specifically function specific modules, i.e., scripts and function calls) that, among other aspects, collectively implement a transport  
25 layer. This layer sits above a Perl web client and Apache Web server daemon processes. Messages are sent using the Perl web client and received by the Apache web server which, in turn, calls the transport layer as a CGI

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(common gateway interface) script. Both the Apache web server and the Perl web client utilize SSL to secure (encrypt/decrypt) the transmission of management data between SEP 200 and web site 20 in conjunction with  
5 TCP/IP processing.

FIG. 21 depicts a detailed block diagram of software 2000 that executes within SEP 200.

10 As shown, software 2000 contains RMM process 2020, CSM process 2030, RMT process 2040 and routines 2050. Here, routines 2050 are themselves depicted as SEP\_GET\_PROFILE module 2120, SEP\_SET\_PROFILE module 2125, SEP\_RMM\_RECEIVE module 2130, SET\_RMM\_SEND  
15 module 2135, all of which have an associated WDDX translation module associated therewith, specifically modules 2123, 2128, 2132 and 2137, respectively. Since the specific information (fields) handled by each module differs, then the various WDDX fields, as defined by a  
20 WDDX hash structure, will differ accordingly amongst modules 2120, 2125, 2130 and 2135, hence, necessitating that each of these modules has a separate WDDX translation module associated with it. WDDX effectively provides an application programming interface  
25 that resides directly over XML which hides the complexities associated with XML coding, thereby simplifying the use of XML -- which otherwise can be quite tedious.

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SEP\_GET\_PROFILE module 2120 is called whenever the CCC requests a configuration profile from SEP 200. In operation, this module retrieves, as symbolized by line 2121, the profile, e.g., profile 2115, stored with SEP database 2110 and encodes the resulting profile into a corresponding WDDX hash structure through WDDX translation module 2123. The resulting WDDX structure is then provided, as symbolized by line 2142, to transport layer (RMS\_TP) 2140 for XML serialization.

SEP\_SET\_PROFILE module 2125 is called whenever CCC 20 intends to download a profile to SEP 200. In particular, this module converts, the WDDX hash structure it receives into a set of Perl structures, reads data from those Perl structures and then, as symbolized by line 2126, writes that data into SEP database 2110 as profile 2115. Prior to writing the incoming profile into database 2110, module 2125 will test the new profile for any errors and, in the event of any errors, will report these errors, as a response, to the CCC and not write that profile into the database.

SEP\_RMM\_RECEIVE module 2130 receives incoming messages from web site 20 intended for RMM process 2020 or for writing into database 2110. These messages supplied, as symbolized by line 2146, by transport layer 2140 are WDDX hash structures, which, in turn, are converted into Perl data with the resulting data then

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provided, as symbolized by line 2133, to RMT process 2030, or, as symbolized by line 2131, to database 2110.

5                   Lastly, SEP\_RMM\_SEND module 2135 receives RMM request data from a stack generated by RMT process 2040. This request data takes three forms: (a) a profile request, i.e., to download a customized profile to the SEP; (b) an alarm delivery request, i.e., to send an  
10 alarm to the SEP; and (c) a poll delivery request, i.e., to send polled status information to web site 20. Module 2135 converts associated Perl data it receives, as symbolized by line 2134, from the RMT process into a corresponding WDDX hash structure through  
15 WDDX translation module 2137. Once that occurs, the resulting WDDX hash is applied, as symbolized by line 2148, to transport layer 2140 for subsequent delivery to the CCC. Thereafter, module 2135 waits for a response from the CCC. Once this response is received,  
20 module 2135 forwards it to RMT process 2040 where, in the case of a returned profile, that response is written into database 2110. The RMT process returns the result of the delivery attempt to the RMM process and, if the attempt is unsuccessful, RMM process 2040 determines where and  
25 when to make another attempt to send the message.

Transport layer (RMS\_TP) 2140 reliably exchanges (sends and receives) data (in the form of

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corresponding serialized XML data) between modules 2120, 2125, 2130 and 2135 in the SEP and peer modules in the CCC. In particular, for any outgoing message from the SEP, layer 2140 first determines its destination IP address (or receives that address from a higher layer). Thereafter, layer 2140 uses a private key associated with SEP 200 to sign the outgoing message, thus permitting the recipient, i.e., here web site 20, to determine the sender and authenticate the message. Thereafter, the outgoing message is applied to web client 2160 which, in turn, calls SSL module 2170 to encrypt the messages and then, via TCP/IP module 2180, posts the message, as an outgoing HTTP message, to a specified web server, e.g., residing at the CCC. Incoming messages from the CCC are handled in essentially a reverse manner. Web server 2150 receives, via TCP/IP module 2180, an incoming HTTP message and applies the message to SSL module 2170 for decryption. Thereafter, transport layer 2140 checks the message, based on its digital signature, to ascertain whether that message originates from the CCC and is authentic. If the incoming message is valid, layer 2140 then applies that message to its corresponding receiving module, i.e., one of modules 2120, 2125 or 2130.

Web server 2150 and web client 2160 bi-directionally communicate with transport layer 2140 as symbolized by lines 2153 and 2163 for incoming and outgoing SEP/CCC messages, respectively. Web server 2150



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and web client 2160 bi-directionally communicate with SSL module 2170 as symbolized by lines 2157 and 2167 for incoming and outgoing SEP/CCC messages, respectively. SSL module and TCP/IP module 2180 bi-directionally communicate with each other via lines 2173 and 2177 for incoming and outgoing messages, respectively. Lastly, TCP/IP layer 2180 bi-directionally communicates over WAN 30 for incoming and outgoing SEP/CCC messages, as symbolized by lines 2183 and 2187, respectively. Web server 2150, SSL layer 2170 and TCP/IP layer 2180 are respectively implemented by Apache web server 350, Open SSL module 340 (in conjunction with X.509 certificate 284) and TCP/IP processing module 370, all of which are shown in FIG. 3A. While the web server uses the Open SSL Apache module, web client 2160 uses a different version of the Open SSL function library.

FIG. 22 depicts a detailed block diagram of software 1950 that executes within web site 20.

As shown and not surprisingly, software 2000 is very similar and provides complementary peered functionality to software 1950 shown in FIG. 19. Software 1950 is formed of CCC\_RMM\_RECEIVE module 2232, CCC\_RMM\_SEND module 2234, CCC\_GET\_PROFILE module 2236 and CCC\_SET\_PROFILE module 2238, all of which have an associated WDDX translation module associated therewith, specifically modules 2233, 2235, 2237 and 2239,

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respectively. Since the information handled by each of modules 2232, 2234, 2236 and 2238 differs, then the WDDX hash structure will differ accordingly amongst these four modules; hence, necessitating that each of these modules  
5 has a separate WDDX translation module directly associated with it. Modules 2232 and 2234 interact, as symbolized by lines 2203 and 2207, respectively, with CCC database 1980; while modules 2236 and 2238 interact, as symbolized by lines 2223 and 2227, respectively, with  
10 application server 2220. This application server, database 1980 and administrative console 2210 (which is typically a workstation) are interconnected via LAN 2215 to permit an individual, stationed at console 2210 and interacting through server 2220, to modify the profiles  
15 stored within database 1980, as necessary, and upload a corresponding profile from CCC database 1980 to a SEP or download a current profile from a specific SEP into that database.

20                   Transport layer (RMS\_TP) 2240, web server 2250, web client 2260, SSL module 2270, TCP/IP module 2280 and links 2253, 2257, 2273, 2283, 2263, 2267, 2277 and 2287 -- all of which also form part of software 1950 -- provide essentially the same functionality (and are  
25 implemented in a very similar manner) as do corresponding elements in software 2000; namely, transport layer 2140, web server 2150, web client 2160, SSL module 2170, TCP/IP

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module 2180 and links 2153, 2157, 2173, 2183, 2163, 2167, 2177 and 2187, respectively.

Specifically, CCC\_RMM\_RECEIVE module 2232  
5 receives incoming requests, via transport layer 2240 and  
as symbolized by line 2242, originating from RMM  
module 2020 executing in a SEP and proceeds accordingly.  
For alarm delivery requests, module 2232 writes a  
corresponding reported alarm into database 1980. Profile  
10 requests cause module 2232 to retrieve a specified  
profile from database 1980 and download that profile via  
transport layer 2240 and its associated processes to the  
SEP. In response to poll requests, module 2232 updates a  
current IP address of a SEP, specified in the request, to  
15 the IP address specified in the request, or to update  
database 1980 with other information, e.g., status,  
specified in the request. After each such request is  
completed (or has failed), module 2232 provides a  
corresponding response to a SEP module that issued the  
20 request.

CCC\_RMM\_SEND module 2234 supports outgoing RMM  
management messages originating/generated by the CCC,  
intended to an RMM process executing on a SEP. These  
25 messages are provided, as symbolized by line 2244, to  
transport layer 2240 for transmission to that SEP.

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CCC\_GET\_PROFILE module 2236 is used to obtain a stored profile from a SEP. This generally occurs, whenever an individual, such as a technician or third-party installer, through interaction with console 2210 appropriately instructs application server 2220, to access a profile stored in a SEP and update web site database 1980 with that profile. To accomplish this, module 2236 encodes a request command into an appropriate WDDX hash structure and communicates that structure to transport layer 2240 for subsequent processing into serialized XML and transport, eventually as an HTTP message, to a destination SEP. Thereafter, module 2236 waits for a response from that SEP. The resulting profile is returned to application server 2220 which, in turn, writes it into an appropriate customer record residing in web site database 1980.

CCC\_SET\_PROFILE module 2238 is used whenever that individual, again through interaction with console 2210, instructs server 2220 to download a profile stored in database 1980 to a specific SEP. To accomplish this, server 2220 retrieves the desired profile from database 1980 and provides that profile to module 2238. This module then encodes the profile in a corresponding WDDX hash structure and then passes that structure to transport layer 2240 for subsequent processing into serialized XML and transport, eventually as an HTTP message, to the specific SEP. Thereafter, module 2238

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waits for a response from that SEP as to its successful receipt of the profile. Once the profile has been received and appropriately processed, that SEP appropriately writes the profile into its database (e.g.,  
5 as profile 2115 in database 2110 shown in FIG. 21).

With the above in mind, we will now discuss, in conjunction with FIGs. 22-26, inter-process interactions that occur within the SEP and web site (CCC) 20 when: the  
10 SEP downloads a configuration profile from the CCC; the CCC downloads a current profile from the SEP; an alarm is reported by the SEP to the CCC; and the CCC, based on a request initiated at the CCC, uploads a configuration profile to the SEP.

15

FIG. 23 depicts inter-process communication that occurs, in response to a request arising within SEP 200 for downloading a configuration profile from web site 20 and storing that profile within the SEP. To  
20 facilitate understanding, the reader should also simultaneously refer to both FIGs. 21 and 22 throughout the following discussions of each of FIGS. 23-26.

This procedure begins whenever SEP 200,  
25 specifically RMM process 2020, issues, as symbolized by line 2305, Get Profile Request 2302. RMM process 2020, directs, as symbolized by line 2305, this request to RMT process 2040 for transmission to the CCC. In response,

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process 2040 provides the request in the form of Perl data, and specifically a request to download a customized profile to the SEP, to SEP\_RMM\_SEND module 2135. This module converts the Perl data it receives into a  
5 corresponding WDDX hash structure and supplies that structure to transport layer 2140 for transmission. Specifically, transport layer 2140 forms a message containing the serialized XML, signs that message and passes it to the web client (client 2160 but not  
10 specifically shown in FIG. 23) for encryption (via SSL). The encrypted HTTP message (containing the WDDX hash structure) is then supplied back to the web client which transmits that HTTP message, as symbolized by line 2315, to the Apache web server 2250 residing at the CCC. Upon  
15 receipt of the HTTP message, the web server decrypts the message (through SSL), and passes it to the transport layer to authenticate the message using the signature appended to the decrypted message and, if authentic, extracts the serialized XML content therefrom. The  
20 resulting serialized XML content is then de-serialized into WDDX hash, with the resulting hash being applied, as symbolized by line 2320, to CCC\_RMM\_RECEIVE module 2232. In response to this request, module 2232 then accesses, as symbolized by line 2230, CCC database 1980 to obtain  
25 the requested profile for SEP 200.

Once this profile, e.g., profile 2340, has been retrieved, CCC\_RMM\_RECEIVE module 2232 receives, as

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symbolized by line 2335, a response containing this profile. This profile is then converted by module 2232 into a set of Perl structures which are, in turn, converted into a WDDX hash structure which is then  
5 provided to transport layer 2240 which serializes that hash into XML. The transport layer then supplies the response to web server 2250 which uses its SSL module to encrypt the XML and then transmits it, as an HTTP response (here being a serialized XML message) and as  
10 symbolized by line 2350, to the web client in SEP 200. The web client then passes the serialized XML message to transport layer 2140 which de-serializes the XML into WDDX hash structure which is provided to SEP\_RMM\_SEND module 2135, which, in turn, converts the WDDX hash  
15 structure into a set of Perl structures, as response 2355. The response is provided, as symbolized by line 2365, back to RMM process 2020 to signify a successful download. In addition, module 2135 also extracts data fields from these Perl structures and  
20 applies, as symbolized by line 2370, those fields (which collectively form profile 2340) to SEP database 2110 which is then written, as symbolized by operation 2375, into this database. The profile is tested before it is written to the database and, if the test fails, the write  
25 to the database is aborted and RMM process 2020 is informed of the failure as indicated by line 2365.

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FIG. 24 depicts inter-process communication that occurs; in response to a request arising within the web site (CCC) 20, for downloading a stored configuration profile from SEP 200 into the CCC.

5

This procedure begins whenever application server 2220 issues, as symbolized by line 2405, a request to download a current profile from the SEP into the CCC database. As noted above, such a request typically originates from an individual interacting with administrative console 2210. This request, typically in the form of Perl data, is directed to CCC\_GET\_PROFILE module 2236 which, in turn, converts it to a corresponding WDDX hash structure (see FIG. 22) after which that structure is provided to transport layer 2240. The transport layer then converts the structure into serialized XML and forms an HTTP message, signs that message (using the secret key of the CCC) and then sends the message to the web client. The web client (client 2260 but not specifically shown in FIG. 23) calls the SSL layer to encrypt the message which is then transmitted, as symbolized by line 2410, to Apache web server 2150 residing at SEP 200.

25

Upon receipt of the HTTP message, web server 2150 provides, as symbolized by line 2415, the decrypted HTTP message to transport layer 2140 which, in turn, authenticates the message using the signature



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contained in the decrypted message. If the message is authentic, then transport layer 2140 extracts the serialized XML therefrom and de-serializes it. The resulting WDDX hash is then applied to SEP\_GET\_PROFILE

5 module 2120 which, specifically through module 2123 (see FIG. 21), converts the WDDX hash structure containing the profile download request into the equivalent Perl request. In response to this request, module 2120 then accesses, as symbolized by line 2420, SEP database 2110

10 to obtain the requested profile, i.e., profile 2425. Once this profile is accessed, a copy of it is returned, as symbolized by line 2430, to module 2120. This module then encodes the profile in a corresponding WDDX hash structure by module 2123. Thereafter, transport

15 layer 2140 forms a serialized XML version of this WDDX hash and, then, a corresponding HTTP message. Once this occurs, the transport layer passes, as symbolized by line 2435, the resulting message, containing the XML encoded WDDX structure, to web server 2150 for encryption

20 and transmission to the CCC. This HTTP response is then transported, as symbolized by line 2440, back to the web client at the CCC and applied by that client to transport layer 2240. In a reverse fashion to that explained above, the transport layer extracts and de-serializes the

25 XML and converts resulting de-serialized XML into a WDDX hash structure containing the requested profile. WDDX translation module 2237 then converts the WDDX hash structure into its Perl equivalent. CCC\_GET\_PROFILE

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module 2236 then writes, from this hash structure, appropriate data fields containing the profile into database 1980, and specifically in a customer record for the customer associated with SEP 200. The

5 CCC\_GET\_PROFILE module also write its result back to application server via 2455, and issues acknowledgement message 2460 back to application server 2220 to suitably inform the server (and hence the individual thereat) that the requested profile has been successfully downloaded to  
10 and stored within the CCC, thus suitably updating its customer records.

FIG. 25 depicts inter-process communication that occurs for providing alarm information from the SEP  
15 to the CCC.

This procedure begins whenever an alarm, here symbolized by block 2505, is generated by the SEP in response to a detected fault in an entity which it is  
20 then monitoring. Here, assume that the alarm is generated by the CSM process 2030. The CSM process provides, as symbolized by line 2510, that alarm to RMM process 2020. This latter process, as described above, logs the alarm and then inserts it depending on the  
25 priority of that alarm in its message queue for RMT process 2040. The RMT process then spawns the Perl interpreter and puts the alarm message on the interpreter stack. To subsequently deliver the alarm to the CCC, RMM

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process 2020 provides, as symbolized by line 2515, that alarm to RMT process 2040 for reliable delivery to the CCC. RMT 2040, in turn, spawns an instance of the Perl interpreter and inserts the alarm data on the Perl stack  
5 (implemented by SEP\_RMM\_SEND module 2135). To appropriately deliver that alarm, RMT process 2040 then provides, as symbolized by line 2520, the alarm data for that alarm to SEP\_RMM\_SEND module 2135. Module 2135 converts the associated Perl data into a corresponding  
10 WDDX hash structure, through module 2137 (see FIG. 21), into serialized XML. Once that occurs, the serialized XML is applied to transport layer 2140 for subsequent delivery to the CCC. Specifically, transport layer 2140 forms an HTTP message containing the serialized XML,  
15 signs that message and then encrypts it (via SSL). The encrypted HTTP message (containing the WDDX hash structure bearing the alarm information) is then supplied to a web client (client 2160 but not specifically shown in FIG. 25) which transmits that message, as symbolized  
20 by line 2525, to Apache web server 2250 situated at the CCC. Upon receipt of the HTTP message, the web server provides the encrypted HTTP message to transport layer 2240 which, in turn, decrypts that message (through SSL), and authenticates the message using the signature  
25 contained in the decrypted message. If the message is authentic, then the transport layer extracts the de-serialized XML, converts it to a WDDX hash structure therefrom and applies that structure to CCC\_RMM\_RECEIVE

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module 2232 which, specifically through its  
WDDX translation module 2233 (see FIG. 22), converts the  
WDDX hash structure containing the alarm information into  
Perl data. In response to this request, module 2232 then  
5 writes, through operation 2535 and as symbolized by  
line 2540, the alarm information into CCC database 1980.

Once the alarm has been successfully written,  
CCC\_RMM\_RECEIVE Module 2232 generates a suitable response  
10 message which is then converted by WDDX translation  
module 2233 (shown in FIG. 22) from Perl data into a WDDX  
hash structure. This hash structure is then provided to  
transport layer 2240 which converts it to serialized XML  
and, using the private key associated with the CCC, signs  
15 this message. The transport layer then encrypts the  
signed message and, as symbolized by line 2555, supplies  
it, as message 2550, to web server 2250 which transmits  
it, as symbolized by line 2560, to the web client in  
SEP 200. This encrypted HTTP message is then passed to  
20 transport layer 2140 which decrypts the message and then,  
using the signature contained in the message,  
authenticates the message. The transport layer extracts  
the serialized XML therefrom, converts it to a WDDX hash  
structure and provides that structure to SEP\_RMM\_SEND  
25 module 2135 which, through its associated  
WDDX translation module 2137, converts the WDDX hash  
structure (containing the response message) into Perl  
data, as response 2565. The response containing the Perl

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data is pushed on the stack by the Perl interpreter and provided, as symbolized by line 2570, back to RMT process 2040 as an acknowledgement. RMT process 2040 also provides, as symbolized by line 2575, a suitable  
5 acknowledgement message back to RMM process 2020 to confirm proper delivery/failed delivery of the alarm information to the CCC and storage of that information within the CCC database.

10                   Lastly, FIG. 26 depicts inter-process communication that occurs, in response to a request arising within web site (CCC) 20, for downloading a stored profile from the CCC to the SEP and writing that profile into the SEP.

15                   This procedure begins whenever application server 2220 issues, as symbolized by line 2605, a request to upload a stored profile from the CCC database into the SEP database. As noted above, and similar to the  
20 scenario, shown in FIG. 24 for downloading a profile from the SEP to the CCC, such a request typically originates from an individual interacting with administrative console 2210. This request, typically in the form of Perl data, is directed to CCC\_SET\_PROFILE module. In  
25 response to this request, this module first accesses, as symbolized by line 2610, CCC database 1980 to obtain a copy of the desired stored profile. Resulting profile 2615 is then returned, as symbolized by line 2620

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and as Perl data, back to the CCC\_SET\_PROFILE module.  
This module, through associated WDDX translation  
module 2237 (see FIG. 22), converts the Perl data to a  
corresponding WDDX hash structure. Thereafter, that  
5 structure is provided to transport layer 2240, which in  
turn, converts the hash structure into serialized XML,  
forms an HTTP message containing the serialized XML,  
signs that message (using the secret key of the CCC) and  
then encrypts the resulting message (via SSL). The  
10 encrypted HTTP message is then supplied to a web client  
(client 2260 but not specifically shown in FIG. 23) which  
transmits that message, as symbolized by line 2625, to  
Apache web server 2150 residing at SEP 200.

15           Upon receipt of the HTTP message, web  
server 2150 provides, as symbolized by line 2630, the  
encrypted HTTP message to transport layer 2140 which, in  
turn, decrypts that message (through SSL), and  
authenticates the message using the signature contained  
20 in the decrypted message. If the message is authentic,  
the transport layer extracts the serialized XML  
therefrom, converts it to a WDDX hash structure and  
applies that structure to SEP\_SET\_PROFILE module 2125  
which, specifically through its WDDX translation  
25 module 2123 (see FIG. 21), converts that structure  
containing the profile to be downloaded into the SEP into  
Perl data, along with accompanying profile write  
request 2635. In response to this request, module 2125

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then writes, as symbolized by line 2640, the profile into  
SEP database 2110. Once this profile is written,  
SEP\_SET\_PROFILE module 2125 generates a Perl response  
which, through WDDX translation module 2128, is converted  
5 into a corresponding WDDX hash structure. Thereafter,  
transport layer 2140 converts the WDDX hash structure  
into serialized XML and then forms an HTTP message, here  
symbolized by response 2650, containing the serialized  
XML, then signs the message using the secret key of the  
10 SEP, and encrypts the message using SSL. Once this  
occurs, the transport layer passes, as symbolized by  
line 2660, the resulting encrypted HTTP message,  
containing the XML encoded WDDX structure, to web  
server 2150 which transports, as symbolized by line 2665,  
15 this message back to the web client at the CCC. In a  
reverse fashion to that explained above, the transport  
layer decrypts the message, authenticates it and, if the  
message is authentic, then extracts, from the decrypted  
message, the resulting serialized XML therefrom and  
20 converts it to a corresponding WDDX hash structure. WDDX  
translation module 2237 then converts this structure into  
Perl data. CCC\_SET\_PROFILE module 2236 then provides, as  
symbolized by line 2675, response message 2670, though in  
Perl form, back to application server 2220 to confirm  
25 that the desired profile has been downloaded into the  
SEP. Before the profile is written by the SEP into  
database 2110, the profile is tested and if the test

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fails, the write to the database is aborted and the appropriate response is returned.

In view of the prior discussion, we will  
5 discuss principal interactions that occur between any  
SEP, such as SEP 200, and web site (CCC) 20 when that SEP  
is initially installed at a corresponding customer site.  
For this discussion, we will assume, for simplicity, that  
the Internet is used as the WAN, as is expected to be  
10 case in the vast majority of (if not all) SEP  
installations. Also, as is the case with every SEP, for  
SEP 200 a customized profile will have been predefined  
and stored within CCC database 1980, where that profile  
defines an anticipated operational and network  
15 environment existing at a customer site in which that  
particular SEP is to function.

Initially, prior to its installation at a  
customer site, SEP 200 is likely to be at a third-party  
20 System Integrator's workshop and need not be connected to  
his network, but only needs to have an analog phone line  
connected to it.

At this point, the only profile stored within  
25 this SEP is the default profile. As such, RMM  
process 2010 detects this condition and causes the SEP to  
attempt to connect to WAN 30 by establishing an Internet  
session, via dial-up (analog) link 59 (see FIG. 1) using



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userid and password information of Netilla Networks, Inc.  
(the present assignee hereof and which owns, administers  
and maintains the CCC) over which SEP 200 will then  
attempt to establish a secured management session with  
5 web site (CCC) 20.

HTTP authentication is used to identify the SEP  
to the CCC. In doing so, SEP 200 will identify itself  
via its hardware MAC (media access control) address to  
10 the CCC.

Once a management session has been established  
with the CCC, the CCC will send a partial configuration  
profile containing SEP-appropriate login and password  
15 parameters for a customer Internet account which that the  
SEP is to use. This information will be identified by  
using the MAC address of the SEP as a key into  
database 1980 residing on the CCC. This database  
contains records of customers and the associated MAC  
20 addresses of the SEPs that have been assigned to these  
customers, along with the customized configuration  
profile for each such SEP.

On receipt of the customer's ISP account and  
25 customization information (that provides its operational  
and network environment) from the CCC, the SEP will tear  
down its existing analog call to the ISP in order to  
minimize the length of these initial calls.

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After successfully obtaining this partial profile, via RMM and RMT processes 2020 and 2040 (see FIG. 20) in the SEP and, via database 1980 (see FIG. 19) and CCC\_GET\_PROFILE process 2236 (see FIG. 22) in the CCC, the SEP will terminate the SSL management session between itself and the CCC. The SEP then establishes a broadband WAN connection having the customer login and password parameter, through which re-establishes its prior session.

At the customer site, the Integrator then uses his/her web browser to go to his/her admin page on the SEPs web server. On that page, there will be a button to download the SEP security information. When this button is pressed, the Integrator is asked for his login/password at the CCC. The Integrator then enters this information which, is then, transmitted securely to the CCC where its database is queried to determine if the user is authorized to have access to the security information of the SEP in question. If the Integrator is authorized, then the key pair along with other sensitive information, e.g., firewall rules, along with the client certificate (e.g., x509 certificate 284 shown in FIGs. 3A and 3B) and customized profile are securely sent to the SEP and applied. Upon successful receipt of the security information, the SEP runs an algorithm, which randomly generates a new root password, and then sends this password to the CCC for archival. The SEP profile

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download is now complete. At the CCC, the private key  
and new root password of the SEP are archived and  
expunged from the database. Now once the security  
parameters have been downloaded to the SEP, all further  
5 management sessions can be secured as both ends now know  
each other's public key. The SEP will then reset itself,  
and use the customized profile received from the CCC to  
correctly configure its various constituent hardware  
components and software modules, as appropriate and as  
10 described above, to its environment.

Though we have described client interaction  
component 1126 as utilizing protocol engine 1160 and user  
browser 15 as utilizing Java applet 1180, both to support  
15 the AIP protocol in order to advantageously increase  
bandwidth efficiency, these components could use native  
RDP all the way to the user browser.

Furthermore, though we have described our  
20 invention as providing remote office functionality in  
terms of file access, e-mail and thin-client application  
hosting, our inventive teachings can be used with any  
other additional office-based application that is to be  
provided to remote users over a network connection, via a  
25 browser. In that regard, another application module  
would be implemented and incorporated into virtual office  
software 400 shown in FIG. 4 -- and similar to those  
described above -- to provide necessary bi-directional,

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real-time protocol translation of user interaction data  
in secure HTTP (or a particular transmission protocol, if  
used in lieu of secure HTTP) into a particular protocol  
used by that other office-based application, and convert  
5 resulting output data (whether graphical or in another  
form) provided by that application-specific protocol into  
secure HTTP (or the intermediate transmission protocol)  
for transmission to the user browser and rendering, as a  
web page, to the user situated thereat. As such, by now,  
10 the reader can clearly appreciate that our inventive  
teachings are not limited to merely providing remote  
access to just office-based file access, e-mail and  
thin-client application hosting functions, though these  
functions are likely to be those most often appearing and  
15 needed in the processing environments for which the  
present invention will likely see use.

Although a single embodiment, with various  
modifications, which incorporates the teachings of the  
20 present invention has been shown and described in  
considerable detail herein, those skilled in the art can  
readily devise many other embodiments that still utilize  
these teachings.